

# WORK ZONE ACCIDENT DATA PROCESS

Offices of Research  
and Development  
Washington, D.C. 20590



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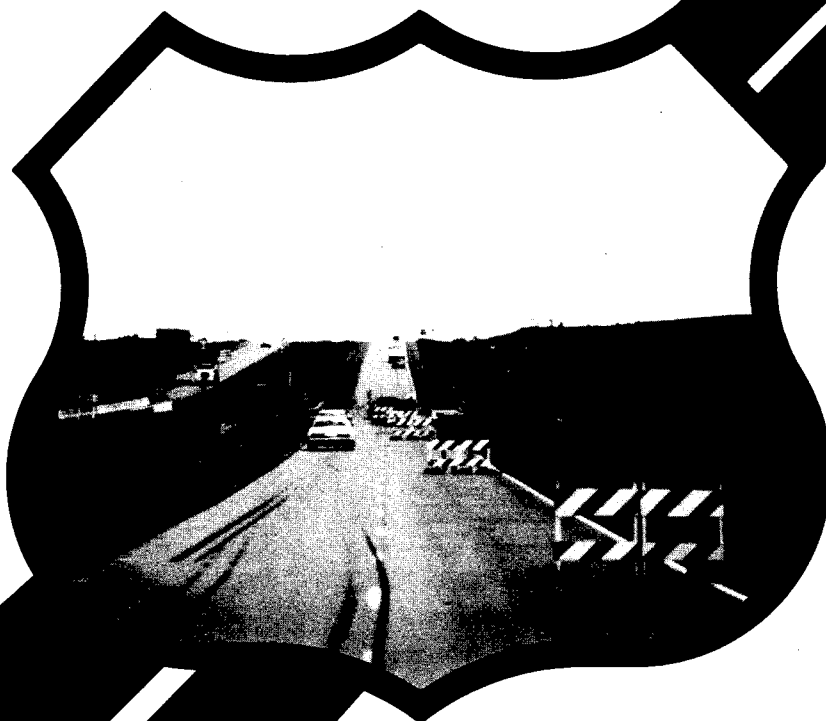
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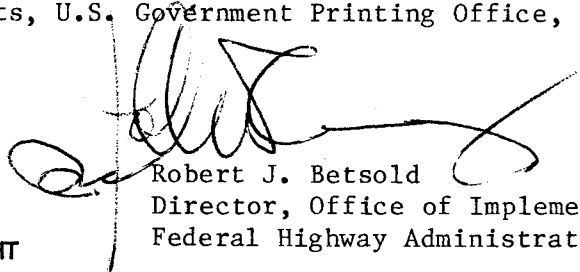
## FOREWORD

The "Work Zone Accident Data" manual describes a data collection and processing procedure intended for construction, maintenance or utility work area accidents. The manual relates to both the short-range need for accident information to provide immediate feedback for correction of traffic control deficiencies, and the long-range need to provide the basis for accident summaries and statewide traffic control standards. This manual is intended for State highway agency construction and maintenance field supervisors and staff, district level engineers, and headquarters level construction and maintenance engineers and accident data specialists.

The manual relates directly to research work being carried out under the Federal Coordinated Program for Research and Development (FCP) Project 1Y, which is to quantify the accident experience in construction and maintenance work zones and to develop desirable traffic control procedures to prevent accidents. The success in developing any improved procedure is determined by the availability of reliable data on the accidents which are occurring.

The participation of the States of Iowa and North Carolina is recognized for putting this procedure into practice and evaluating it. In particular, Mr. Fred Walker of the Iowa DOT and Mr. Jim Murphy of the North Carolina DOT are to be thanked for their assistance in conducting this trial effort.

Distribution of the manual, is being made to each Federal Highway Administration Region and Division Office. Additional copies are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.



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16. Abstract <p>During construction, maintenance, or utility activities on a roadway open to traffic, the ability of the roadway to carry traffic is often reduced, and there are increased hazards due to the work activity and workers in the roadway. Liability suits resulting from work zone accidents have increased dramatically in recent years. This fact and the need to keep traffic control compatible with the ever changing construction or maintenance situations has created the need for a "Work Zone Accident Data Process."</p> <p>The work zone accident data process is a data collection and processing procedure which starts at the construction and maintenance work site and transmits information through the regular communications channels to the State highway agency headquarters. The process is a supplement to regular police accident reporting and is used to provide both short range (immediate project application) feedback as well as long range summaries (statewide application). The process provides a flexible, systemized data gathering method suitable for use at either selected locations, at sites using selected traffic controls, or at all construction or maintenance sites.</p>			
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## I. MANUAL OVERVIEW

### A. Introduction

During construction, maintenance, or utility activities on a roadway open to traffic, the ability of the roadway to carry traffic is often reduced, and there are increased hazards due to the work activity and workers in the roadway. Many accident studies comparing accident rates before and during work activities show that accidents do increase during work activities. Liability suits resulting from work zone accidents have increased dramatically in recent years, which reemphasizes the Federal Highway Administration's (FHWA) position on traffic safety in roadway work zones.

On July 5, 1978, FHWA Order 5180.1B, "FHWA Alert Bulletin Procedure," was issued. It requires the reporting of traffic accidents (a) when five or more fatalities occur or (b) when a chain reaction collision occurs; and (c) when a death or disabling injury to workers on the job or to the general public occurs.

On October 13, 1978, FHWA issued a regulation (FHWA 6-4-2-12) pertaining to all federal aid construction projects. This regulation contains many procedures assuring that adequate consideration is given to the safety of motorists, pedestrians, and work force personnel.

Two mandatory procedures described in the regulation are:

1. The highway agency shall designate a qualified person who will have primary responsibility and sufficient authority to assure that the traffic control plan and other safety aspects of the contract are effectively administered.

- a. On small projects this person may be the resident or project engineer.

- b. On large projects this person should be a designated person who is trained in traffic control measures. The individual would be assigned to this task on a full-time basis and would not be responsible for other duties.

- c. Such persons may be responsible for one or more projects, depending upon project magnitude and proximity to other projects.

2. Work zone accidents shall be evaluated on both a short-term and long-term basis.

- a. On a short-term basis, the responsible person makes arrangements to obtain accident information, including accident locations, as quickly as possible so that current operational problems can be evaluated and appropriate changes can be made in the traffic control plan.

b. On a long-term basis, a sampling of accidents that occur in work zones is identified and analyzed. This information should be used to correct deficiencies in traffic control standards and to improve the content of future traffic control plans.

The purpose of this user's manual is to describe a process that the person responsible for work zone traffic control can use to analyze work zone accidents. This complete process is called the "work zone accident data process." The process is suitable for application on a State-wide basis or on a limited scale, to gather data only at selected construction or maintenance projects.

## B. Organization of This Manual

The following chapters detail each procedure in the work zone accident data process. Chapter II defines work zone accidents and incidents. Chapter III explains procedures for the collection of accident, incident, and other data that may be useful in the work zone accident data process. Chapter IV explains the analysis of the various data types. Chapter V describes implementation of corrective actions. Chapter VI explains the accident and other summaries made at the district and state levels. Chapter VII gives procedures for implementing the work zone accident data process. The appendices give procedures for collecting and analyzing traffic volumes, traffic conflicts, vehicle speeds, and accident and traffic control photographs. Also included in the appendices are definitions and copies of blank data collection forms.

## C. Objectives

The process described in this manual will enable the work zone project manager to identify traffic control deficiencies through a systematic procedure of data collection. The process can be used both for taking immediate corrective actions and for developing a data base for future analyses. This process involves various levels of work zone operations and these are described in this handbook along with the duties of key persons.

## D. Levels of Work Zone Responsibility

This manual stratifies work zone responsibility into three levels:

- Level 1 - Project Level
- Level 2 - District Level
- Level 3 - State Level

In some states, there may be four levels of responsibility: project, residency, district, and state. In these states, the resident engineer may perform some of the project and district level functions.

Primarily, this manual is intended for those responsible for the project level of work zone traffic control. However, district and state level procedures are also described so that project level personnel will be aware of the intended long-term use of the data they collect.

Figure 1 shows the different levels of work zone responsibility. The organizational framework in the diagram is intended only as a model. It is not meant to completely parallel any one state's organization. For example, the names of organizations involved in accident data preparation, processing, and analysis vary greatly from state to state. The organizational model shown in Figure 1 should be adaptable enough, however, that a state can substitute the names of specific sections at each stage.

The work zone accident data process is described below by levels of responsibility.

### 1. Level 1 - Project Level

The first stage of the work zone accident data process includes those people who manage the day-to-day progress of the work activity and all work zone traffic control devices. The person who is in charge of the work activity at the project level may be known by different titles, among which could be resident engineer, project engineer, project manager, chief inspector, maintenance foreman, or supervisor. This person may also oversee a number of inspectors. In many states, one inspector is designated as the traffic control inspector or safety officer. In this manual the term "project manager" is used to mean the person who is in charge of the work zone traffic control whether this person is actually the project manager, resident engineer, or a safety officer.

This level also includes the police officer who investigates and reports traffic accidents and all the construction contractor's personnel.

The goals of the process at this level are to have many eyes looking for traffic problems and to have designated individuals to solve problems when they are detected.

### 2. Level 2 - District Level

In most state highway departments, there is a level of responsibility between the project level and the state level. These offices may be called districts, divisions, or regions; in this manual, they are referred to as "districts." The district level usually includes construction and maintenance sections and a traffic engineering section (although some states do not have district traffic engineers). This level of the work zone accident data process also includes the second level of state police organizations (usually called "troops"), local police headquarters, utility company headquarters, and permit sections.

At the district level a work zone review team comprised of representatives of traffic engineering, construction, maintenance, utilities and police would be useful. There should also be a person at the district level available as a roving investigator.

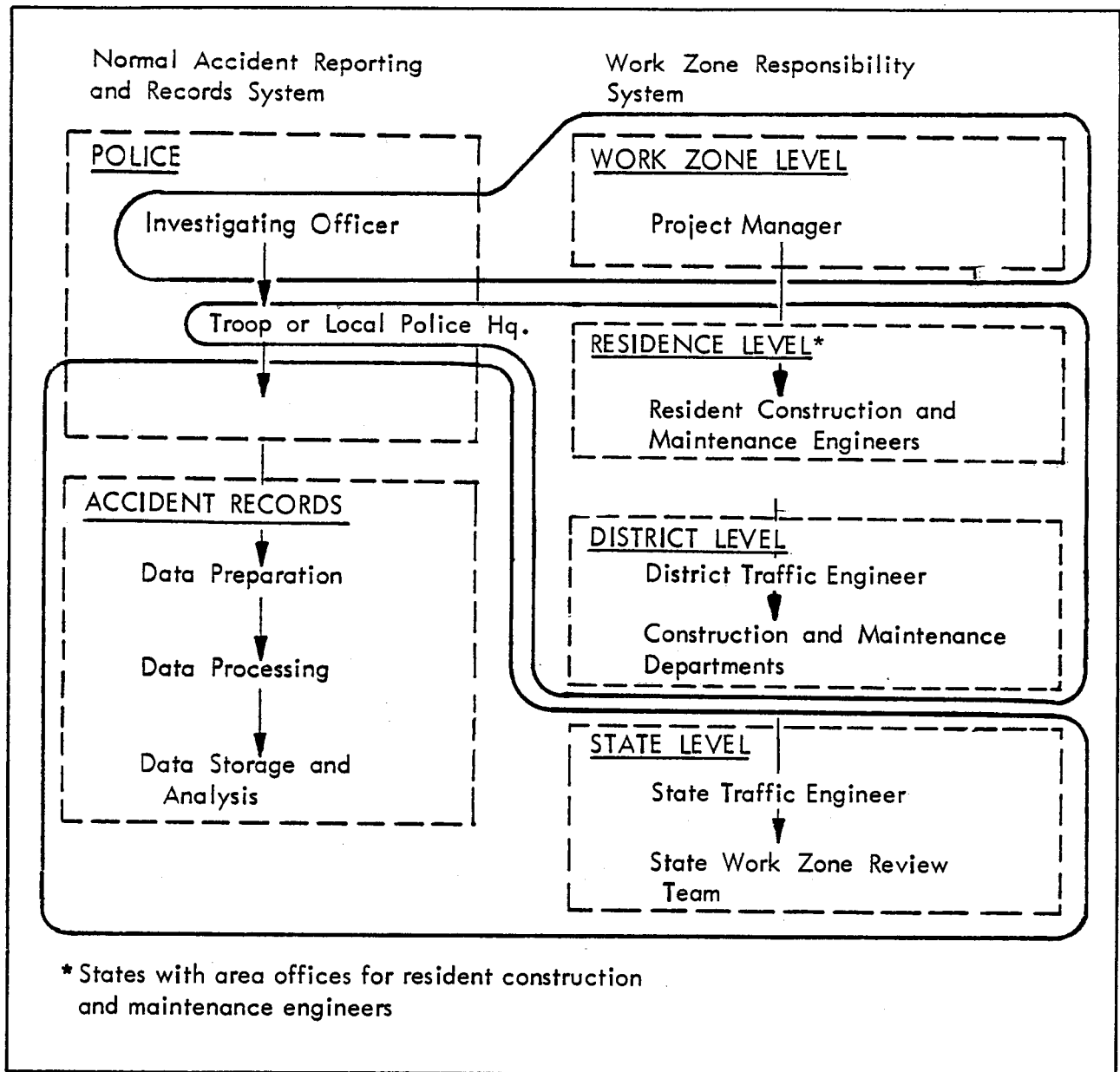


Figure 1 - Levels of Work Zone Responsibility

The district is responsible for reviewing project accident summaries and deciding what changes in standards and procedures for preparing traffic control plans should be recommended.

### 3. Level 3 - State Level

The third level includes state highway department headquarters personnel, such as the state traffic engineer and the state construction and maintenance engineers. Organizations that process or analyze accident data after reports leave the police troop or local police headquarters are also in this level. The agencies included in the accident records system vary from state to state, of course, but they may include the state police headquarters, the department of revenue, the department of public safety, the department of motor vehicles, department of highway safety, department of transportation, and the state highway department.

The forming of a state work zone review team is required. Such a team will normally be comprised of representatives of traffic engineering, design, construction, maintenance, utilities, and police. FHWA division engineers may also be represented. A lead office should be designated to prepare draft recommendations for the review team.

## E. Summary of Work Zone Accident Reporting Procedures

Procedures required in each level of the work zone accident data process are described briefly below. The procedures are described in greater detail in later sections of the manual. A process flow chart for a typical state highway agency is shown in Figure 2.

### 1. Project Level Procedures

a. Notification Procedures: The goals of the notification procedures are to get information about all reportable accidents and to have the project manager or representative be aware of all accidents occurring within the project limits. To meet these goals, it is necessary to establish a two-way notification procedure so that work zone personnel will alert the police when an accident occurs and the police will ensure that the project manager is aware of all accidents occurring within the work zone--even if they happen at night or on weekends.

b. Procedures Performed by the Project Manager: The project manager is the key person in the work zone accident reporting process. The responsibilities of the project manager include those listed below:

- Establish formal notification procedures;
- Brief personnel (contractor and state);
- Investigate the relationship of accidents to the existing work zone traffic control system;

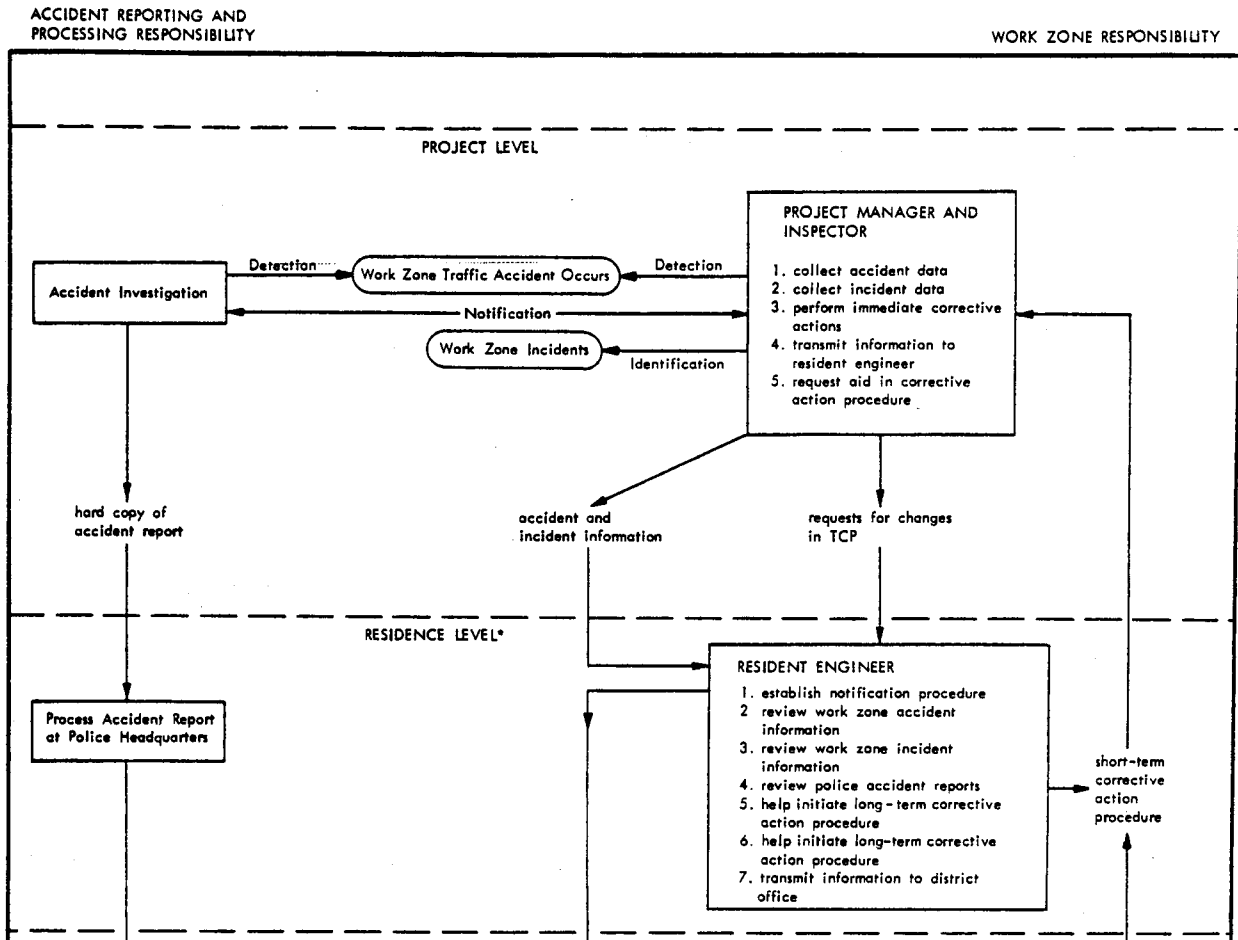


Figure 2 - Work Zone Accident Data Process.



- Establish and maintain periodic two-way communications with local police having jurisdiction in the project area.
- Identify types of incidents that will be reported and investigate incidents such as unreported accidents, damaged barricades, and traffic backups;
- Perform immediate corrective actions;
- Analyze data; and
- Transmit required information to the resident engineer or district traffic engineer.

As mentioned above, the notification procedures must be coordinated with the police agency investigating work zone accidents. Accident investigation by the project manager can be done in several ways, but the focus should be on the status of the traffic controls and roadway conditions at the time of the accident. The investigation does not necessarily involve being at the scene before the involved vehicles are moved or interviewing drivers or witnesses, but the investigation should be conducted soon enough after the accident to record traffic controls at the time of occurrence. It should not duplicate data collected during the course of police investigations.

The police accident report form or a verbal report about the accident should be obtained from the investigating officer. However, there should not be an over-reliance on the information in the police accident report. Police officers are often concerned primarily with driver fault and may not note roadway or traffic control circumstances at the time of the accident.

The circumstances of the accident can be documented in the project diary, in traffic control inspection reports, and on special accident report forms. Photographs of the accident scene and traffic controls are also a valuable means of accident data documentation.

The project manager, inspectors, and all contractor personnel should search for any clues that may indicate a potential hazard in the work zone. In this manual the event that caused such clues including evidence of unreported accidents, are called "incidents." Data on these incidents can be collected by observing traffic operations or from complaints from the driving public or from the police. These critical incidents or patterns of incidents should be documented in inspection reports or in the project diary.

After collection of accident and incident information, the project manager should analyze the data in relation to project traffic operations and decide what action to take. Some examples of actions to take are: to make changes in the traffic control plan, to take immediate corrective action; to ask for further help in analyzing the problem; or to gather

additional data, such as on traffic conflicts or traffic volume, for use in analysis of the traffic control plan. Chapter IV of this manual includes a list of possible changes that might be needed in the traffic control plan based on the types of accidents or incidents that have been observed.

At regular intervals (at least monthly) the project manager should send the accident and incident information to the district traffic engineer or, alternatively, to the resident engineer. For construction or maintenance jobs of less than one month's duration, the information should be submitted at the end of the job.

c. Procedures Performed by the Investigating Officer: Extra work or reports required of the investigating officer is kept to a minimum under this procedure. As part of the notification procedures, the officer makes sure that the project manager is aware of all accidents occurring in the work zone. In some cases this may involve telephoning the project manager or representative at night or on weekends to report accidents. If this arrangement is not workable, project personnel should take the initiative of regularly contacting the police. The police officer is expected to use the standard police accident report form. This form should be checked to make sure it includes a category for identifying work zone accidents.

One optional procedure that may be used by the investigating officer, or a dispatcher at the troop office, is to telephone the district traffic engineer to give details about the accident or to send a copy of the police accident report to the project manager or district traffic engineer.

## 2. District Level Procedures

Although the work zone accident data process starts at the project level and can be implemented only at that level, it is more effective if personnel at the district level are also involved. The district traffic engineer is important in the work zone accident reporting process, being the most available source of traffic engineering information for the project manager. To facilitate rapid response to work zone accidents and incidents, a roving investigator is recommended. This person would make regular visits to work sites and help the project manager in detecting and analyzing work zone traffic control problems.

a. Procedures Performed by the District Traffic Engineer:  
The duties of the district traffic engineer can be divided into two general areas:

- Determination of changes needed in the traffic control plan of a specific project; and
- Development of project accident summaries.

The district traffic engineer, or a roving investigator, is to analyze the accident and incident data collected by the project manager to decide if changes are needed in the traffic control plan. If the project manager has made immediate changes in the traffic control plan, these changes

should be checked by the district traffic engineer or representative. The district traffic engineer is also responsible for summarizing traffic accidents and control problems in project accident summaries and for forwarding these summaries to the state level where statewide patterns can be analyzed.

b. Procedures Performed by District Construction and Maintenance Sections and Utility Companies: These administrative units are responsible for training their member project managers in the work zone accident data process. Members of these departments may also initiate corrective actions as well as initiate new policies developed from the statewide annual work zone accident summary.

c. Procedures Performed by the Roving Investigator: This person may also be referred to as the "district safety officer" or the "district traffic control inspector" and is actually the district traffic engineer's field representative. The roving investigator should be on call to aid project managers at jobs where accidents are occurring and to prepare project summaries. The frequency with which the roving investigator visits a job is, of course, dependent on the size of the area to be covered and the number of work zones in the district, as well as the number and severity of accidents which are occurring on the project. The roving investigator should also make frequent visits to those projects where unique circumstances and special or potential problems exist.

### 3. State Level Procedures

The personnel at the state level are responsible for preparing the statewide work zone accident summary. This summary and all project summaries are analyzed to determine whether new or revised policies or standards of work zone traffic control need to be developed. This procedure would normally be conducted on an annual basis. As shown in Figure 2, the state traffic engineer and staff normally prepare the statewide work zone accident summary. The state traffic engineer and other members of the state work zone review team should decide what changes are needed in policy or standards.

## II. DEFINITION OF WORK ZONE PROJECT LIMITS, ACCIDENTS, AND INCIDENTS

In this section, work zone project limits, work zone accidents, and work zone incidents are defined. These definitions are presented so that everyone in the highway agency who works on highway projects, analyzes accident and incident data, or makes decisions about work zone traffic control procedures understands their meanings and thinks alike in this respect. It is important that information about accidents and incidents is accurately recorded and analyzed. Only in this way can it be determined if traffic control procedures are generating problems or allowing motorists to proceed safely through work zones.

### A. Work Zone Project Limits

The purpose of the signing used in work zones is to alert and guide motorists safely through the work area and to protect the people working on or near the roadway. The driver is alerted when entering a work zone by means of an advance warning sign, which is intended to make the driver more cautious and to look for additional warning signs. The first warning sign will have a message such as ROAD CONSTRUCTION AHEAD or ROAD WORK AHEAD, depending on the type of work activity--construction, maintenance, or moving maintenance work (includes striping, sweeping, mowing). For work zone accident and incident data collection purposes, the location of the first advance warning sign denotes the beginning of the work zone.

After driving through a stationary work zone, motorists are informed that they are leaving the work area and can resume normal driving. Again, there are specific signs, such as END CONSTRUCTION or END ROAD WORK, that are used for this purpose. The location of the last construction or maintenance sign is used to denote the end of the work zone.

On one-way roads such as freeways, where the opposing direction of travel is separated, the project limits are the beginning and ending work zone signs. A typical roadway with one-way traffic is shown in Figure 3. Accidents occurring on the roadway for opposing direction of travel would not be considered work zone accidents.

On roadways with two-way traffic, the sign denoting the beginning of a stationary work zone in one direction may not be at the same point as the sign denoting the ending of a work zone in the opposite direction. In this situation, the project limits are the advance work zone warning signs for both directions, as shown in Figure 4.

For moving operations, the back-up vehicle displaying the appropriate warning sign designates the beginning of the work zone. For moving operations, and also some short-term stationary operations, an END ROAD WORK sign may not be required. For these projects, the end of the work area is the end of the work zone.

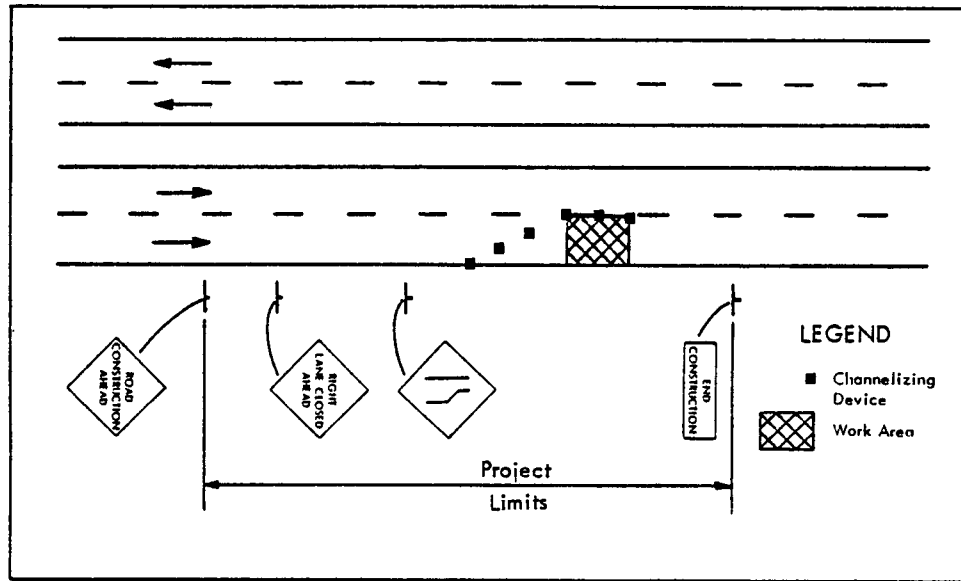


Figure 3 - Project Limits - One-Way Traffic

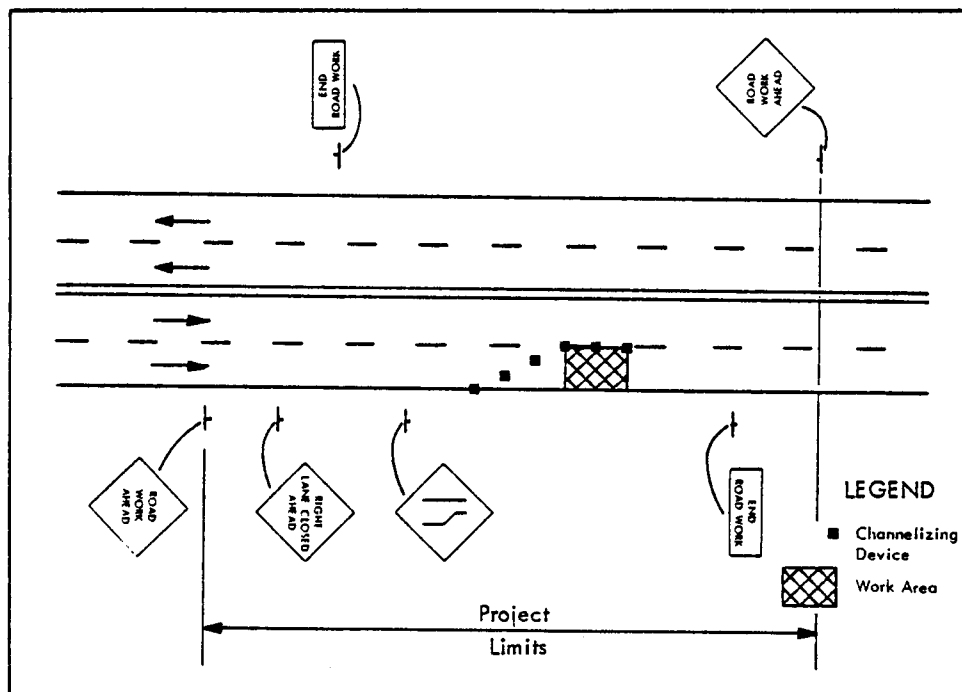


Figure 4 - Project Limits - Two-Way Traffic

The log points of the beginning and ending project limits, as located in the field, are accurately recorded and are used to obtain the project length in miles or feet. Any day-to-day changes in project length should be noted. The project length is one of the values used to determine vehicle-miles of travel, which is an important component of determining accident rate. For moving operations, a daily log of changes in work zone length and/or location needs to be maintained.

## B. Work Zone Accidents

A work zone accident is defined as any accident that occurs within the project limits of a work zone which is reported and investigated by a police agency. The purpose of defining work zone accidents in this all-inclusive manner is to avoid forcing the officer investigating the accident to make a judgment on whether an accident was caused by, related to, or influenced by the work zone. This judgment will be made by the project manager and traffic engineer during the investigation and analysis of the work zone accident.

A similar event that is neither reported nor investigated by the police is classified as an incident and is described in Subsection C below.

Work zone personnel should investigate every accident occurring within the project limits. If it appears the accident is not work-related, such as when a vehicle collides with another vehicle at an intersection, then the investigation will involve merely recording a minimum amount of information about the accident and noting that it was not work-related. If the accident does appear to be work-related, such as when a vehicle collides with a work vehicle or is sideswiped near the taper of a lane closure, then a more thorough investigation should take place.

## C. Work Zone Incidents

A work zone incident is an event or evidence of an event that indicates a hazard or potential accident situation. By identifying and correcting these real or potential accident situations, future accidents may be prevented. One example of an incident is an accident that was neither reported nor investigated. More than likely, this would be a minor mishap in which the motorist was able to drive the vehicle away from the accident location before being detected by work zone personnel or the police. Evidence left from the incident, such as damaged barricades or broken glass, could indicate traffic control deficiencies depending on where, when, and how the situation occurred. Evidence of near misses, brake light applications, and unsafe driving actions as traffic drives through the work zone also may indicate potential problems. These events, formally called traffic conflicts, are less severe and occur more often than traffic accidents. If there appear to be many traffic conflicts within a short period of time, it is an indication that there are problems with the work zone traffic control system.

Appendix A includes information on how to observe conflicts. Counting conflicts may be too time-consuming for project personnel but can be done by roving investigators or other district personnel.

At times it is easier for someone not directly involved with installation and operation of the work zone traffic controls to point out deficiencies in the procedures. Motorist complaints are a valuable source of information about potential problems. Police officers who patrol roads under repair also should be asked to provide information that could be used to improve traffic control deficiencies. Also, project or other state highway agency personnel (i.e., maintenance, administrative, etc.) should be asked to drive through and identify any conditions that they believe to be unsafe.

### III. DATA COLLECTION

Accident information and incident information about unreported accidents are both helpful in determining the causes of traffic accidents. Collecting data on traffic volume and traffic conflicts can help identify the severity of potential hazards before accidents occur. Photography can be used as a supplement to the information learned during other data collection processes. These are all important to the analysis process. The information learned during an initial work zone inspection conducted immediately after the traffic control plan is implemented may identify potential hazards that can be corrected before any accidents ever occur.

This section of the manual covers inspection procedures for new installations, accident data, incident data, traffic volume data, traffic conflict observation, use of photography for data collection; and conducting spot speed studies. In addition, this section explains when each type of data should be collected, the types of data to be collected, and techniques that are useful in the data collection procedure.

#### A. Inspection Procedures for New Installations

A newly implemented work zone traffic control plan may not be operating as well as it was originally designed to work. To lessen hazards to motorists and workers, traffic controls should be inspected and analyzed immediately after the traffic control plan is implemented and traffic is driving through the work zone. This subsection presents procedures for performing this inspection.

The preconstruction conference is a good time to discuss inspection procedures, including who will perform the inspection, who has the authority to make changes, who can be called upon for advice, and how the contractor is involved with inspections and changes in traffic control devices. The project manager, being responsible for the project, is the logical person for this job. On projects that have a person assigned to monitor traffic control procedures, that person could perform the inspection. On projects with complex traffic control plans, the designer or someone from the district traffic department could do the inspection. For objectivity, it is wise to have someone who is not familiar with the project perform the initial inspection of a newly implemented traffic control plan. This person may identify potential hazards that are overlooked by the people directly involved in placing the traffic control devices.

Two ways to perform the initial inspection are by driving through the work zone and by watching how traffic drives through the work zone. A drive-through inspection enables the observer to see the traffic control devices and perform the maneuvers as the other drivers are doing. This inspection is done in all lanes, in both directions, on crossroads, during the day and the night, and from any entry or exit points within the zone. Any other routes, such as detours, that have work zone traffic on them are

to be driven also. Traffic flow patterns can also be observed from a position along the shoulder of the roadway that enables the traffic control inspector to see traffic drive through a particular portion of the work zone. If the observer is unable to view the entire work zone from one position, separate observations from different positions will be needed. Other vantage points, such as overpasses, hillsides, buildings, or even airplanes, may offer better views of the entire traffic flow pattern.

The results of the inspection are summarized by the project manager or inspector, and any deficiencies and changes in the traffic control plan are recorded in the project manager's diary or a departmental traffic control inspection report. The inspection results will contain information about the specific devices, how the arrangement of devices permits traffic to flow, and any changes that were made to the traffic control plan.

A tape recorder is a good way to record immediate thoughts and observations. Photographs, time-lapse film, video tape, or photologging are good for capturing both the driver's and a bird's-eye view of the work zone. Pictures have the advantage of being a permanent record of the traffic control plan as it is installed on the highway. All recordings and pictures are to be keyed to the project and the particular traffic control plan.

During the initial inspection, traffic control procedures are compared with the plans and specifications. Signs are evaluated to see if they communicate their message and are located properly. The location and length of lane tapers and the spacing of devices are checked. Any work zone traffic signals are installed and put in working order. Any existing signs or signals that are not needed are removed or covered. By this time, all proposed pavement markings should have been added and nonapplicable pavement markings removed if the work zone is stationary and of sufficient duration.

If any flaggers are used, their performance and appearance is checked to see that they are using the proper flagging techniques and are wearing reflective vests and hardhats. More important, it should be determined if the work zone can be operated efficiently without flaggers. If so, there is no need to expose flaggers to additional hazards. If there are other workers in the area near the traveled way, they are to be properly dressed and to avoid unnecessary exposure to traffic. It should be determined whether work vehicles are parked far enough away from the traffic.

The initial inspection includes a night visit to the work zone. The entire arrangement of traffic control devices is checked to determine if the devices properly delineate the path through the work zone. Any signing that is not needed after the workday ends is covered. All steady-burn and flashing hazard lights should be working properly. Any reflective material used for signs and barricades should be clean and bright. New pavement markings should be bright and should denote the pavement boundaries. All evidence of unwanted pavement markings should be removed so that motorists will not be misled into following the wrong, and possibly dangerous, path. Results of the night inspection are recorded in the same manner as are the day inspection results.

Long-term stationary, short-term stationary, and moving-maintenance work zones have requirements specific to each type of work activity. Long-term stationary operations must be evaluated on a regular basis to ensure that the work zone traffic control plan is operating as intended and to keep contractors from becoming complacent about maintenance of the devices. Since hazards are present for a long time, local drivers will become familiar with the operational characteristics of the work zone. Regular evaluations, such as conflict studies, ensure that work zone procedures are operating properly and that traffic control requirements are being met. Random visits by district personnel are helpful in pointing out problems. For long-term projects, the proper maintenance of traffic control devices is especially important. All reflective material must be cleaned periodically, and lights and batteries must be replaced. If the work area within a long work zone is periodically moved, the advance warning signs will have to be moved also.

Because short-term stationary work zones are not in any one location for very long, they may be more hazardous to motorists. Special care should be taken to perform needed maintenance on the devices and to use proper traffic control procedures. If the work area will be in place for more than a day, all unnecessary signing should be covered at night. The project manager should make daily inspections to ensure that proper procedures are followed.

Moving operations, which include pavement striping, sweeping, mowing, and pothole repair, may block a through lane while providing very little advance warning. Drivers will have to move out of the closed lane and past a slow-moving vehicle. Besides driving past the work vehicles to evaluate this type of operation, the observer should drive along the shoulder. The work vehicles should be properly signed and lighted. It should be determined if the work party is creating hazardous congestion, if there are any unsafe or erratic maneuvers by the work vehicles, and if the workers who must venture into the roadway are properly dressed and protected by a back-up vehicle. The project manager performs regular evaluations, and these are supplemented by random visits by district personnel.

All newly implemented work zones need to have an initial day and night inspection to ensure that the traffic control plan is operating as intended. If problems appear, they should be corrected as soon as possible. If the project manager is not confident enough to identify and implement the corrections, advice on solutions should be sought. The person to be consulted for advice should have been identified at the preconstruction conference. Close liaison with this advisor will help ensure safe and efficient work zone traffic control procedures.

## B. Accident Data

Accident data is the most important type of data collected in the work zone accident data process. The details of each work zone traffic accident should be analyzed in order to determine whether the work zone operations and traffic controls are causing or contributing to the accident.

If so, the work zone features contributing to the accident should be redesigned to maximize the safety of drivers and workers. The first key to collecting complete work zone accident data is a well-designed accident notification procedure.

## 1. Accident Notification Procedure

As discussed earlier, the ideal procedure would be when the project manager is automatically notified of all accidents whether during normal working hours or at night or weekends. However, in practice this may not happen. The project manager may not be aware of accidents. Also, the project manager, traffic control inspector, or contractor's personnel may be aware of damaged barricades, bent guardrails, or other indications of unreported accidents, but they may not report these indications to the police who normally patrol the work zone. The goal of the notification procedure is to have police learn about and investigate all reportable work zone accidents and to have the project manager or representative be aware of all accidents occurring within the project limits.

To meet this goal it is necessary to establish a two-way notification procedure in which work zone personnel alert the police when an accident occurs and the police alert the project manager of all accidents occurring within the work zone, particularly those that occur at night or on weekends.

Before the construction season begins, the police should be asked to cooperate in establishing a work zone accident notification procedure. The groundwork for this notification procedure is laid at the preconstruction conference by informing all parties, including contractors and police, of the importance of speedy notification of accidents. If police are not represented at preconstruction conferences, they must be contacted before the start of work to discuss the notification procedure. For moving maintenance or utility work, it may be necessary to establish a procedure in which police are informed of work locations weekly or even daily and asked to report all work zone accidents. During work activities, speedy notification of the police and the project manager is especially important because of the need for an accident investigation by both parties.

## 2. Recording Accident Data

Accident data can be recorded in the project manager's diary, in a traffic control inspection report, or on a special accident report form. A sample accident report form for work zone accidents is shown in Figure 5. No matter where the accident data are recorded, the items discussed in this subsection should be included.

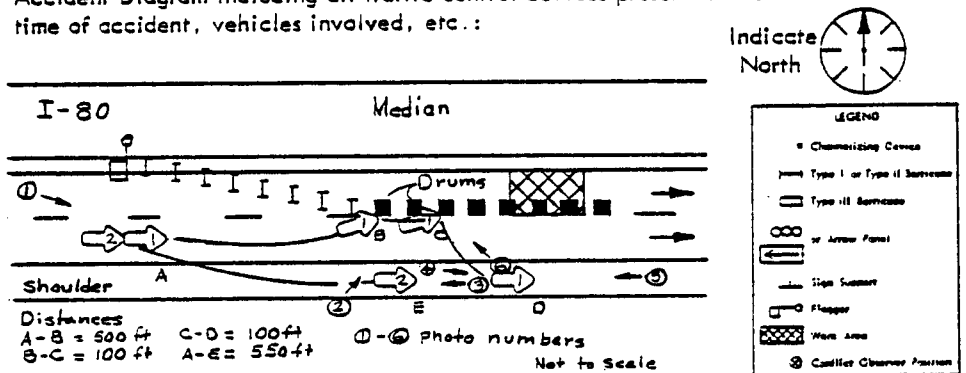
The purpose of the accident report form is to record information about the accident and the work zone traffic control existing at the time of the accident. The form is divided into three parts: the accident description, the accident diagram, and the accident narrative.

# WORK ZONE ACCIDENT REPORT

## Accident Descriptors:

Date Monday, June 23, 1980 Time 2:00 P.M.  
 Route No. (Name) I-80 Driver Names #1 Mary E. Roberts  
#2 Ralph Roberts  
 County Lancaster  
 Weather Clear and dry Milepost 407 - 408  
 No. of Vehicles Involved 2 Severity #1 was injured  
 Location at left lane closure taper Investigated by Willie Davidson  
 Have other accidents of similar nature occurred in this zone? No  
 If yes, give dates \_\_\_\_\_

Accident Diagram including all traffic control devices present at the time of accident, vehicles involved, etc.:



Accident Narrative: Vehicles were eastbound in right lane. Vehicle #1 slowed and was hit in the rear by vehicle #2. Driver #1 stated that she saw the flagger motion, which meant for her to stop. So she tried to stop and was struck by vehicle #2.  
Recommendation: Check flaggers technique.

Resulting action: I drove through the work zone at three times of the day to check flagger's technique. Each inspection showed that the flagger was using proper procedures.  
 Time and date that action was taken: 9:00 AM, 11:00 AM, 2:00 PM 6/24/80  
 Name and title: Willie Davidson, Project Manager

Figure 5 - Sample Work Zone Accident Report

The accident description section of the report gives basic information about the accident and allows for matching this report with the police accident report. A copy of the police accident report or a description of the accident is to be obtained from the investigating officer. Information contained in the police accident report form will be needed by the district traffic engineer to prepare the district work zone accident summary. There should not be an over-reliance on the information in the police accident report as it is normal for the police accident report to take a week or longer to reach the district office, and this is too long to delay before initiating corrective measures in the work zone. Also, the officer completing the police report will not have the knowledge of the work zone traffic controls that is possessed by the project manager. The accident description section also contains items that allow the project manager to relate this accident to other accidents of the same type or within the same area of the work zone.

The accident investigation conducted by the project manager should focus on the status of the traffic controls in use at the time of the accident. All traffic controls should be shown in the accident diagram section of the accident report form, including advance signing, flaggers, or police vehicles. (It may be possible to refer to photographs or a traffic control plan if traffic controls are extensive.) The accident diagram will show the paths of vehicles involved and their relationship to the work activity and the work area traffic controls. The project manager may have to make this determination from information given by the investigating officer or witnesses such as inspectors or contractor personnel. For the sake of uniformity, a legend is shown in the accident diagram section of the report with symbols to represent various traffic control devices. An accident diagram template with the traffic control device symbols plus other symbols for vehicles, lane lines, curves, etc., is useful for drawing accident diagrams. Templates may be purchased at stores selling police equipment or engineering drawing supplies.

The third section of the report form is the accident narrative. The accident narrative describes what happened in the accident, with special emphasis on the involvement of the work activity at the time of the accident; problems (if any) observed in the work area traffic control devices; and comments of those involved, such as the investigating officer and witnesses. Information about the condition of traffic control devices or the presence of specified devices should be included. The narrative description of the report normally contains three types of information: facts, statements, and recommendations. Care should be taken that statements (or opinions) are not presented as if they were facts. The use of the three types of information as separate paragraphs under each heading in the narrative section is sometimes beneficial, especially if the narrative is extensive or it is possible to confuse facts and statements.

The work zone accident report in Figure 5 was designed for recording all information about the accident. However, some state highway agencies have developed special accident reporting forms to be used by project personnel who are investigating work zone accidents. The accident investigators in those states would use the state-developed forms.

There will be times when the accident investigator will have more information than can be recorded on the work zone accident report form. Figure 6 is a sample work zone accident report supplement. The supplemented report contains an accident investigation check list, legend, and space for notes and comments. (The sample information contained in Figure 6 supplements that presented in Figure 5.) The accident report supplemental form can also be used with any highway agency accident report forms. When used, the completed supplemental report should be stapled to the completed accident report.

### C. Incident Data

The collection of incident data can be useful in two ways, either to obtain additional information after an accident has occurred or to point out a hazardous condition before an accident occurs. It is important that incident information be recorded so that it can be used by more than one person, can be referred to at later times, and can be used as a record of past conditions.

Like accidents, incidents can be recorded in the project manager's diary, in traffic control inspection reports, or on special incident report forms. A sample incident report form is shown in Figure 7. This form is used to record information about incidents that are observed. If it is decided that a formal study is required to collect and analyze traffic conflict incidents, then Appendix A - Traffic Conflict Counts should be consulted. This appendix contains descriptions of the various types of conflicts as well as procedures for collecting and analyzing conflict data.

The Incident Type section on the incident report form is used to describe and classify the incident that occurred. Several common types of work zone incidents are listed. However, the definition of an incident is very broad and many other situations may be classified as work zone incidents. There is also space in this block to write a description of the incident if the description is not evident from the list of incident types.

The Incident Descriptors section of the report is used to record basic information about the incident. There is also space to record previous incidents of the same type or others that have occurred in the same area of the work zone.

The third section of the report is for the incident diagram. A legend similar to the accident symbol legend is used to diagram the apparent paths of the vehicle or vehicles involved in the incident or to show the location of damaged channelization devices, skid marks, debris, etc.

The Resulting Action section of the report is used to document any traffic control changes or other actions that were taken. If, for example, the locations of some advance warning signs were changed because of incidents in the transition area, the reasons for the changes should be documented. The reasons for not changing the locations of the other advance warning signs should also be documented.

## WORK ZONE ACCIDENT REPORT SUPPLEMENT

### WORK ZONE ACCIDENT INVESTIGATION CHECKLIST

1. Notify police.
2. Record date, route, and driver names to be able to obtain the police investigation report.
3. Photograph traffic controls present, including reference distances.
4. Describe the accident using facts, statements, and recommendations.
  - Facts - time, description of the scene, vehicle damage, physical evidence, passenger information, etc.
  - Statements - by drivers, witnesses, and police
  - Recommendations - follow-up action to be taken
5. When hazards or problems are documented, solutions and actions taken must be documented.
6. Sketch the accident diagram. Include a north arrow, highway names and numbers, paths of vehicles, relationship to work activity, and photograph locations. Make sure the information in the diagram agrees with the other information in the report.

TYPES OF COLLISIONS	LEGEND	SYMBOLS
Head On Left Turn Rear End Sideswipe - Opp. Direction Sideswipe - Same Direction Cut of Control Right Angle Fixed Object	Moving Vehicle Backing Vehicle Non-involved Vehicle Pedestrian Parked Vehicle Overturned Vehicle Fixed Object	Channelizing Device Type I or Type II Barricade Type III Barricade Arrow Panel Sign Support Flagger Work Area

Notes and comments: All dual advance warning signs (48"x48") were in place and included "40 mph" advisory speed signs.

1. "ROAD CONSTRUCTION 1 MILE"
2. "LEFT LANE CLOSED AHEAD"
3. "LEFT LANE CLOSED 2000 FT"
4. "P1"
5. "FLAGMAN 500 FT"
6. "END CONSTRUCTION"

The police accident report was obtained Tuesday July 1, 1980.

Figure 6 - Sample Work Zone Accident Report Supplement

# WORK ZONE INCIDENT REPORT

## Incident Type:

Observed unreported accident ☒ Erratic maneuvers ☐  
 Damaged traffic control device ☒ Rear-end conflicts ☐  
 Skid marks on vehicle track off-roadway ☐ Lane change conflicts ☐  
 Vehicles stopping in roadway ☐ Slow vehicle conflicts ☐  
 Traffic backups ☐ Slow-to-merge conflicts ☐  
 Complaint from drivers, police or workers ☐ Unsafe driving actions ☐  
 Shoulder or lane encroachments ☐

Other (Explain) \_\_\_\_\_  
 Description of the incident Truck with a wide load hit guard rail  
and kept on going.

## Incident Descriptors:

IR-80-6(88)122

Date 6/11/80 Time 4:30 PM Route No. I-80 Job No. 1

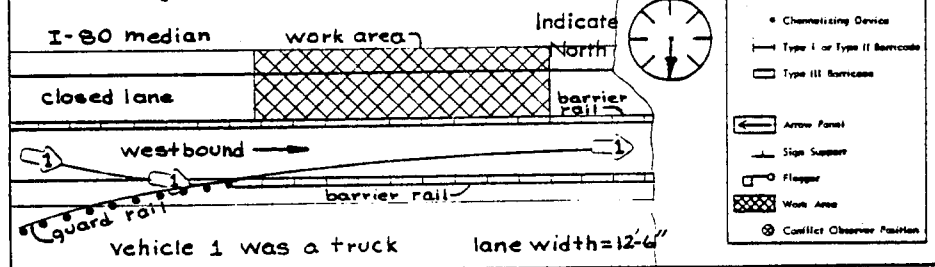
Milepost or Location near MP 172 Weather partly cloudy

Number of vehicles involved 1

Have other similar incidents occurred in this area? No

If yes, explain \_\_\_\_\_

## Incident Diagram



Resulting action: Repaired minor damage to the guard rail.

Time and date that action was taken: 6:00 PM 6/11/80

Name and title: D. M. Quiston Project Manager

Figure 7 - Sample Work Zone Incident Report

#### D. Traffic Volume Data

Traffic volume data are needed when analyzing work zone safety and operational problems. Average daily traffic counts are used to compute accident rates, and hourly counts will show periods of heavy traffic flow and may be used for scheduling work activity. Traffic volume data should be collected as a routine activity since it is desired to know the relative exposure of the work zone feature under examination and to be able to compare the relative safety of two or more work zones. The use of traffic volume data in the work zone accident data process is described in detail in Appendix B.

#### E. Traffic Conflict Observation

The traffic conflict technique is a method of observing and classifying traffic events. These counts can sometimes be used to describe reasons why accidents are occurring. Traffic conflict counts can also indicate potential hazards before traffic accidents occur. If traffic control problems are occurring and the solutions to the problems are not apparent, the project manager should consider performing a traffic conflict study. Definitions, collection, and analysis of traffic conflict data are discussed in Appendix A.

#### F. Use of Photography for Data Collection

The use of photographic techniques can be of help in collecting data about work zone traffic accidents and traffic control problems. Photographic techniques used to document the positions of vehicles and traffic control devices ensure that no important details of the accident investigation or traffic control inspection are overlooked. The photographing of accident scenes, traffic controls, and traffic operations are discussed in detail in Appendix C.

#### G. Conducting Speed Studies

If speed controls are part of the work zone traffic control plan, or speed control is an identified traffic control problem, the project manager or roving investigator may want to conduct a spot speed study. Appendix D discusses the procedure for collection and analysis of spot speeds.

#### IV. DATA ANALYSIS

The value of collected data is lost if the data are not used to find solutions to work zone traffic control problems. This chapter explains how the data collected in the work zone accident data process are analyzed to determine problems in traffic controls and the changes needed.

The analysis procedure described in this manual has five steps, listed as follows:

1. Initiate an analysis whenever there are indications of problems in the work zone traffic control plan, such as an accident or a series of repeated similar conflicts or other incidents;
2. Analyze the details of the accident or incident. If records are available, look for accident or incident patterns. Determine: (a) when accidents or incidents are occurring, (b) where accidents or incidents are occurring, (c) the types of accidents or incidents that are occurring, and (d) the severity of accidents or incidents;
3. Consider requesting additional data collection to supplement available data;
4. Identify problems and corrective actions using Tables 2, 3, and 4 (pp. 34 to 38) which detail possible traffic control changes based on selected indicators;
5. Turn over findings to a multi-discipline review team for consideration and action.

##### A. Accident Analysis

Accidents are the most serious indication of work zone traffic control problems. When one occurs, all possible steps should be taken to determine its cause and to make corrections that will reduce the probability of additional accidents of the same type.

If an accident occurs within the project limits, this does not automatically mean that a change in work zone traffic controls is required. Accidents are a statistically rare occurrence, the cause of any one accident is very hard to determine, and most accidents usually are the result of a combination of factors.

One should not be misled by thinking that most accidents are the fault of an inattentive, drunk or otherwise unfit drivers. The responsibility of those working on the roadway is to prevent accidents that are related to construction or maintenance work. The occurrence of an accident that is construction-related is sufficient reason to initiate an analysis of the accident. The occurrence of two or more accidents that are related to the same cause should be given even quicker accident analysis.

The first step in determining the cause is to examine the relationship of the accident to the existing work zone traffic controls. If there appears to be a connection, the problem can be further examined by collecting conflict data or other data on work zone traffic operations that might be helpful, such as, if available, accident data on the roadway before the work project started. If a significant increase in accidents has occurred in the project area since the work zone was established and if there are significant differences between the type of accidents occurring during the work activity and the type occurring before the work began, there is good reason to suspect the problem may be associated with the work zone traffic control or the work activity.

As the number of accidents in the work zone increases, it becomes more urgent to determine if the accidents are associated with the work activity or work zone traffic controls. The following discussion covers the various methods of analyzing a set of accident data. It may also be advisable to request help from the district traffic engineer or roving investigator.

The analysis of a set of accident data should be done by classifying the accidents and by determining what classifications occur most frequently. Accidents are most commonly classified by: location; accident type; time of day; weather, light, and road surface conditions; and severity. These accident classifications are summarized in Table 1.

The location of the accident can be classified as at an intersection or at another location in the work zone. For many work zones, particularly those that are stationary, the location of accidents can be specified by the area of the work zone. It is important to divide work zones into areas because there are varying traffic control requirements in each area based on driver responses required for safe operation. These areas are common to all types of work zones and are described below. Figure 8 illustrates five areas within a work zone requiring a lane closure.

Advance Warning Area - Begins with the first information to drivers that they are approaching a work area. On high-speed expressways, the Advance Warning area may begin 1 to 2 miles upstream of the work areas. In this area of the work zone, the driver is given information about the actual condition of the roadway ahead and the actions that will be required to travel through the work zone. Although no physical restrictions narrow the roadway in the Advance Warning area, there are often slowing and merging maneuvers as drivers adjust their speed and position based on their concept of the safe path through the work zone.

TABLE 1

METHODS OF ACCIDENT CLASSIFICATIONLocation

- . Intersection
- . Milepost
- . Areas of the Work Zone
  - Advance Warning Area
  - Transition Area
  - Buffer Space
  - Work Area
  - Termination Area

Accident TypeAt Intersections or Interchanges

- . Right angle
- . Rear-end
- . Sideswipe or merging
- . Head-on
- . Pedestrian (or worker)
- . Fixed object
- . Overturning
- . Right turn
- . Left turn

On Highway Sections

- . Ran off road
- . Overturn
- . Fixed object
- . Pedestrian (or worker)
- . Rear-end
- . Sideswipe

Time of Day

- . 6:00 AM to noon
- . Noon to 6:00 PM
- . 6:00 PM to midnight
- . Midnight to 6:00 AM

Weather, Light, and Road Surface ConditionsWeather

- . Cloudy
- . Clear
- . Rain
- . Snow

Lighting

- . Daylight
- . Darkness
- . Dawn or dusk
- . Artificial lighting

Surface

- . Dry
- . Wet
- . Snow or ice

Severity

- . Property damage only
- . Nonfatal injury
  - Possible injury
  - Nonincapacitating
  - Incapacitating
- . Fatal

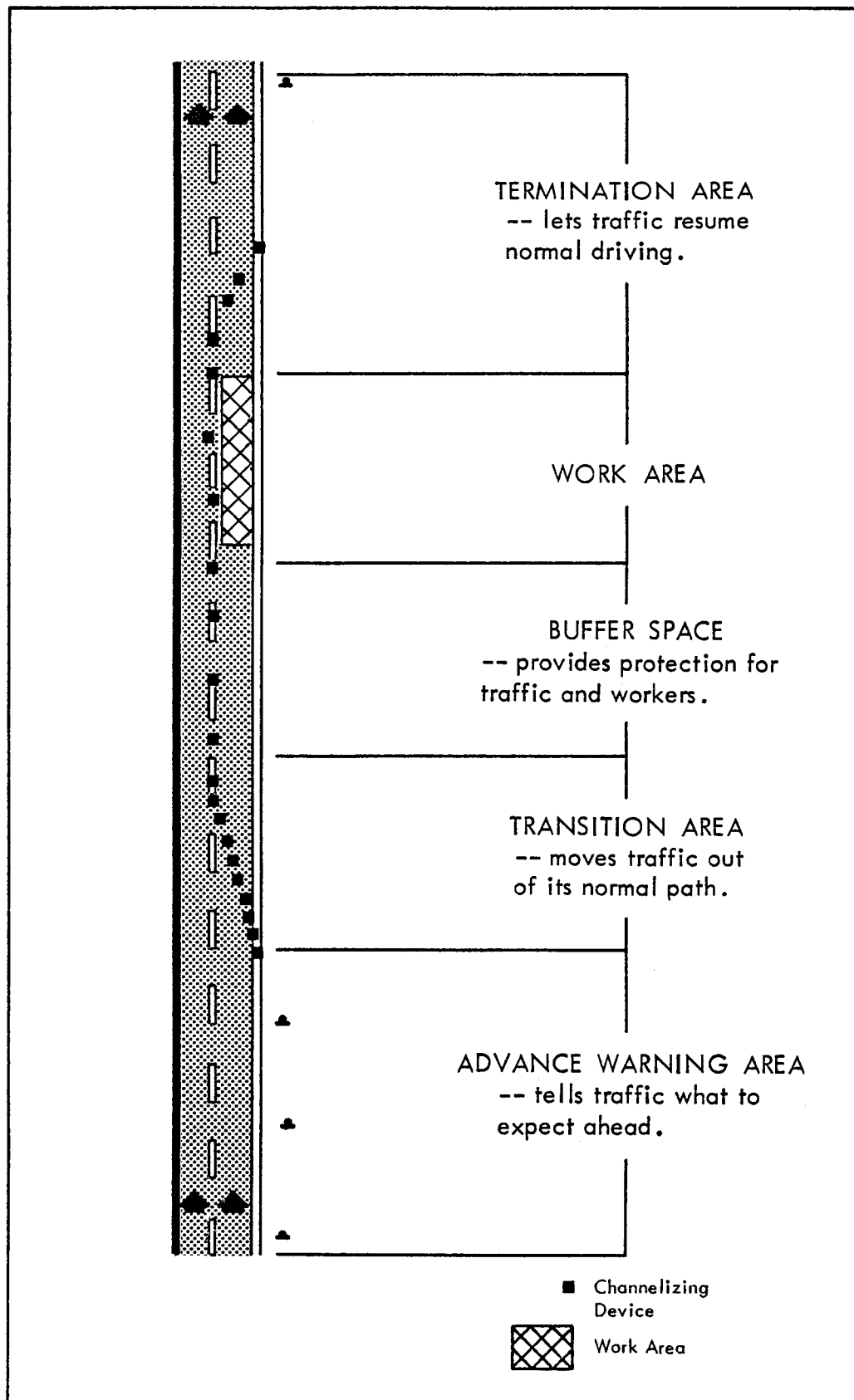


Figure 8 - Areas of Traffic Control in a Work Zone

Transition Area - Begins at the point where traffic is laterally channelized from the normal highway lanes by devices such as cones or barricades arranged in a taper, to guide traffic around the work area to the part of the roadway that is open through the work zone.

Buffer Space - The open or unoccupied space between the transition and work areas. The buffer space allows a margin of safety for both traffic and workers by providing room to stop before the work area if a driver fails to negotiate the transition.

Work Area - That portion of the work zone where work is going on or is going to be done. The work area is completely closed to traffic and is set aside exclusively for workers, equipment, and construction materials. Work areas may remain in fixed locations or may move as work progresses. The work area is usually delineated by channelizing devices or shielded by barriers to exclude traffic and pedestrians.

Termination Area - The area downstream from the work area where traffic returns to the normal traffic lanes of the roadway. It extends from the downstream end of the work area to the END CONSTRUCTION or END ROAD WORK sign, and may contain channelizing devices arranged in a taper.

One method of summarizing the location of work zone accidents is by drawing a collision diagram. A sample collision diagram for a stationary work zone is shown in Figure 9. The collision diagram is sketched on a plan of the work zone that shows work zone traffic controls and the location of crossovers, lane closures, etc. If there is space on the collision diagram, other details should be noted about each accident such as:

- . Date, day of week, and time of accident;
- . Weather or pavement conditions;
- . Light conditions; and
- . Number of injuries or fatalities.

Also, any special circumstances or driver comments about the accident should be noted, such as "accident occurred during period of traffic backup" or "driver did not perceive lane closure early enough to merge into open lane."

After all accidents have been sketched, the collision diagram is analyzed to determine evidence of accident patterns. The type of accident occurring in each part of the work zone, the time of occurrence, and the weather conditions are also to be identified.

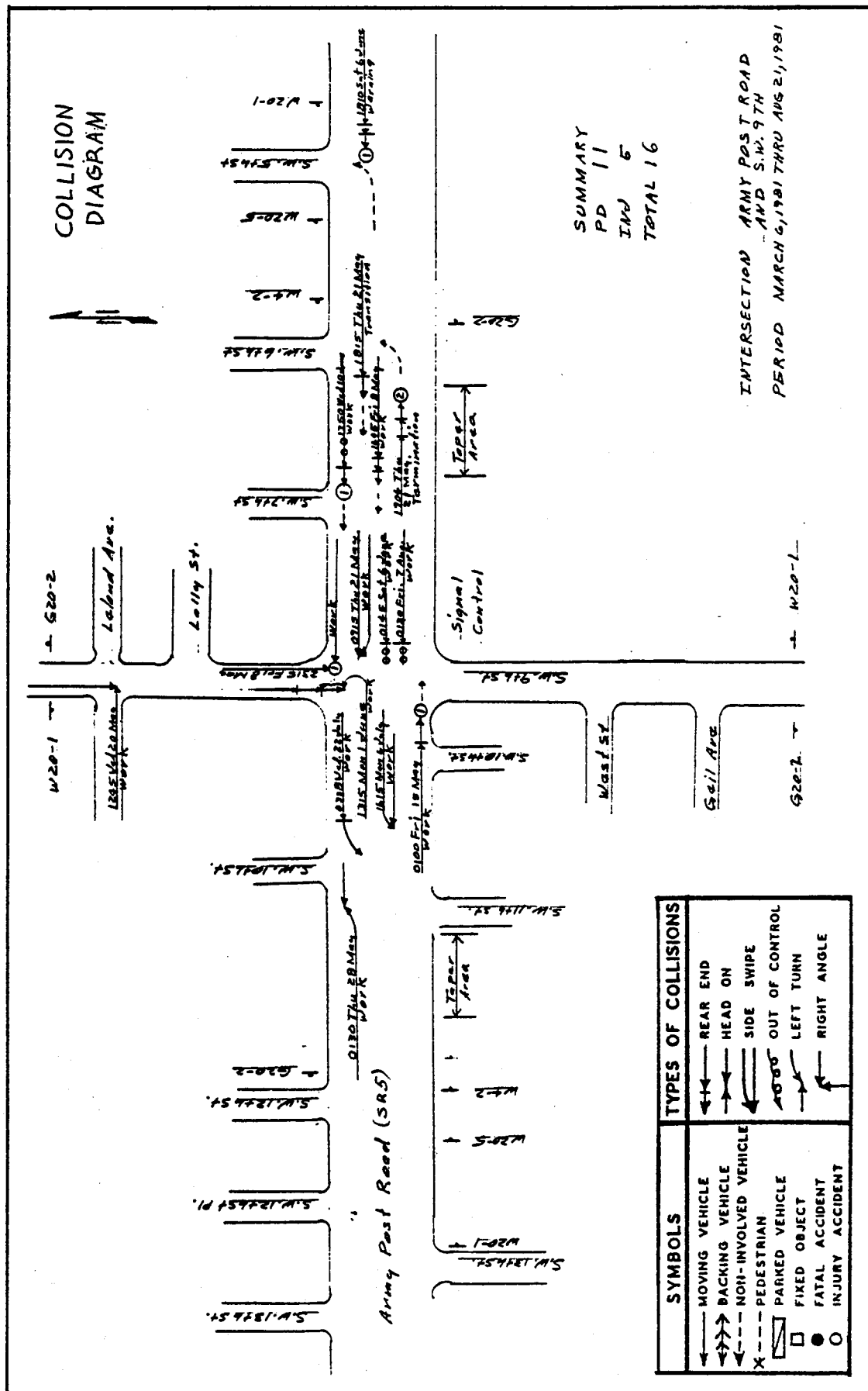


Figure 9 - Collision Diagram

In addition to analyzing accident data by classification, the accident rate should be determined. This is the ratio between the number of accidents at a location and the exposure to traffic volume. For most work zones, the accident rate is determined in the same manner as for any highway section. For a highway section, the accident rate is defined as:

$$\text{Accident Rate } R = \frac{(N)(10^8)}{(D)(ADT)(L)}$$

where R = accident rate in accidents per 100 million vehicle-miles

N = number of accidents during the project duration

D = duration of the project in days

ADT = average daily traffic of the work zone in vehicles per day

L = length of the project in miles

For example, if a project 5.03 miles long that lasted 191 days with an average daily traffic volume of 6,000 vehicles experienced nine accidents, it would have an accident rate of:

$$R = \frac{9 \times 10^8}{191 \times 6,000 \times 5.03} = 156.1 \text{ accidents per 100 million vehicle miles of travel.}$$

Accident rates for before construction can be compared to during construction time periods; between work zones of the same type in different parts of the state; or between work zones and all roads of that type in the state. A 1977 MRI report<sup>1</sup> states that the average increase in accident rates for before-during construction of 79 projects in seven states was 6.8%, with 24% of the projects experiencing rate increases of 50% or more and 31% of the projects experiencing rate decreases.

## B. Incident Analysis

Work zone incidents are analyzed in the same manner as work zone accidents. That is, the analyst looks for patterns of incidents and tries to determine probable causes and possible traffic control changes that will reduce hazards. If the project manager or traffic control specialist performing the analysis is responsible for simultaneous work zone projects, similar patterns of incidents existing on each project should be looked for. This will develop a data base of problems and solutions. Discussions with other project managers may also lead to solutions.

The construction, maintenance, or traffic departments at the district office may be aware of similar problems in the district, or even statewide. These departments will also be developing data bases containing accident, incident, construction, maintenance, and traffic information. An incident that may seem like a random event to a project manager may actually be part of a pattern of incidents when combined with data collected by analysts at the district office.

The analysis of traffic conflict data (a special type of incident data) is described in Appendix A, Traffic Conflict Counts.

### C. Analysis of Other Data

Analysis of traffic accidents and incidents may provide some indication of the extent of hazard present in a work zone. The analysis of other more common data will also be valuable in identifying shortcomings in traffic control procedures or actual traffic patterns which, if left unaltered, could generate accidents or adversely affect traffic operations.

#### 1. Traffic Volume

Traffic volume counts are conducted to determine the numbers of vehicles, types of vehicles, times of peak flow, and direction of traffic flow. There are many types of traffic volume counts used in the design and analysis of street and highway networks. Traffic volume counts can be conducted in time intervals ranging from 5-min increments to continuously, depending on the intended use of the data. The use of traffic volume data is discussed further in Appendix B.

Before a highway construction or maintenance project begins, the capacity of the altered roadway is analyzed to determine if the presence of a work zone will adversely affect traffic flow. If so, the highway agency will need to reduce traffic by rerouting some of the vehicles or increasing capacity by widening the traveled roadway.

#### 2. Speed Data

Although not collected in every work zone, speed data can be beneficial in zones where accidents or incidents are linked to high speed or where vehicle speeds vary greatly. Analysis of speed data is described in Appendix D.

#### 3. Traffic Control Plans and Photographs

When performing an analysis, the project manager should use traffic control plans and photographs to document procedures as well as for clearer understanding of problems and possible solutions. The first drive-through inspection, which includes photographing the work zone, should be used to compare the design of the traffic control plan with the actual installation of devices. This is also a good time to determine if the plan, as designed, is operating safely.

Any changes in the location or arrangement of devices should be recorded on the plan and, for complete documentation, also photographed. If possible, an additional set of traffic control plans should be obtained so that traffic control problems or future changes can be analyzed using the scale drawings. These plans can then be used for sketching possible changes and for working out design problems.

The locations and dates of any traffic conflict, volume, or speed studies should be recorded on the traffic control plan. The use of a reference code (date, day of the week, time, location, etc.) will enable easy retrieval of data collected in various studies so that they can all be related to the work zone and used to determine the effectiveness of traffic control changes.

Traffic control plans should also be used to record accident information. By recording the type, date, and location of each accident on the plan, a continuous collision diagram will be produced. This may help identify traffic problems and trouble spots within the work zone and will help other project managers and traffic engineers identify similar problems and solutions in other work zones.

Recording as much pertinent information as possible on the traffic control plan creates a permanent record of the traffic control history of the project and documents the effort that the project manager and project staff expend in providing a safe path through the work zone.

#### D. Problem Identification and Correction

When accidents, incidents, and other data have been analyzed and the pattern of accidents or incidents has been determined, traffic control changes to alleviate the problem must be sought. Tables 2, 3, and 4 are designed to cover a set of possible safety or operational problems and traffic control changes in a work zone to be made in response to a pattern of indicators.

The tables are organized by indicator classification. The three classifications used are: indicators by (a) location of problem; (b) accident type; and (c) time-of-day or weather conditions.

To use the table, the project manager should find the indicator description that best typifies the results of the accident, incident, or other traffic data analysis; and then decide what traffic operational or safety problem may have caused or contributed to the occurrences of the accident, incident, or other indicators. With each problem all possible traffic control changes should be considered.

Table 2 - Problem Identification and Correction by

LOCATION OF PROBLEM

LOCATION	POSSIBLE PROBLEM	POSSIBLE TRAFFIC CONTROL CHANGE
1. Accidents or incidents occurring in the <u>warning or approach area</u> of the work zone.	Insufficient advance warning signs.	Add advanced warning signs. Increase size of advance warning signs. Use variable message signs or arrow boards.
	Speeds too high or high variance in speeds.	Add advisory speed signs. Provide speed enforcement patrols. Install rumble strips.
	Improper flagging technique.	Train flaggers. Move flaggers upstream. Replace flaggers with signals.
	Insufficient work zone traffic capacity.	Provide alternate routes. Increase capacity by routing traffic onto shoulder. Change work schedule to exclude peak traffic periods.
	Signs not visible at night.	Mount signs at correct height above roadway. Install flashing warning lights or signs. Replace signs not meeting visibility requirements. Illuminate signs.
	Improper lane changes.	Add arrow board. Lengthen taper. Move taper position upstream.
2. Accidents or incidents occurring in the <u>transition area</u> of the work zone.	Insufficient advance warning.	Add advance warning signs. Increase size of advance warning signs. Move taper upstream to increase sight distance. Use variable message sign or arrow boards.
	Lack of sufficient sight distance to taper.	Move taper upstream to increase sight distance.
	Improper merging at lane closures.	Add arrow board. Move taper upstream to increase sight distance. Lengthen taper.
	Insufficient work zone capacity.	Provide alternate routes. Increase capacity by routing traffic onto shoulder. Change work schedule to exclude peak traffic periods.
	Transition not visible at night.	Illuminate or reflectorize channelizing devices. Add arrow board. Add temporary pavement markers.
	Speeds too high or high variance in speeds.	Provide speed enforcement patrols. Install rumble strips. Add advisory speed signs.
	Advance warning signs too far upstream from transition.	Move warning signs more frequently.

TABLE 2 (concluded)

LOCATION	POSSIBLE PROBLEM	POSSIBLE TRAFFIC CONTROL CHANGE
3. Accidents or incidents occurring in the <u>work area</u> of the work zone.	Workers or equipment too near traffic stream.	Move equipment. Add portable concrete barriers. Instruct workers to wear hard hats and safety vests. Instruct workers to stay as far as possible from traffic stream. Install Highway Advisory Radio.
	Motorists watching work activity.	Install sight barriers.
	Speeds too high or high variance in speeds.	Install rumble strips. Provide speed enforcement patrols. Add advisory speed signs.
	Access and egress of work vehicles into traffic stream.	Relocate work vehicle access and egress points. Furnish flaggers.
	Insufficient work zone traffic capacity.	Provide alternate routes. Increase capacity by routing onto shoulder. Change work schedule to exclude peak traffic periods. Install Highway Advisory Radio. Reduce length of work area.
4. Accidents or incidents on two-lane, two-way traffic operations on divided highways.	Passing in no-passing zone.	Reduce length of section. Provide police enforcement. Provide cones or tubes on centerline of two-way section. Provide concrete median barriers. Change to alternate type of work zone such as bypass roadway or detour. Use variable message signs.
	Insufficient work zone traffic capacity	Provide alternate routes. Build bypass roadway. Widen lanes.
5. Accidents or incidents on one lane sections with alternating direction traffic operations.	Excessive vehicle queues and delays.	Reduce length of section. Provide pace vehicle.
	Improper flagging technique.	Train flaggers. Move flaggers upstream. Replace flagger with signals.
6. Accidents or incidents occurring on curves.	Inadequate design for prevailing vehicle speeds.	Improve curve design. Improve edge line delineation. Add advisory speed plates.
7. Accidents or incidents occurring at median crossovers.	Insufficient crossover delineation.	Remove old pavement markings. Install new pavement markings. Install raised pavement markers. Install lights on channelizing devices.
	Speeds too high or high variance in speeds	Provide speed enforcement patrols Improve crossover design. Add advisory speed signs. Install rumble strips.
	Shifting of cargo loads in trucks	Improve crossover design. Provide speed enforcement patrols. Add advisory speed signs.

Table 3 - Problem Identification and Correction by

ACCIDENT TYPE

ACCIDENT TYPE	POSSIBLE PROBLEM	POSSIBLE TRAFFIC CONTROL CHANGE
1. Fixed object accidents.	Narrow work zone roadway.	Widen roadway by moving channelizing devices or by using narrower devices. Improve reflectivity and delineation of devices. Illuminate or reflectorize channelizing devices. Increase roadway width by routing traffic onto the shoulder.
	Insufficient advance warning.	Move taper upstream to increase sight distance. Add arrow board.
	Drums rolling into travel lane	Replace drums with barricades. Increase traffic control device inspection frequency.
	Too many traffic control devices in or near roadway.	Provide portable concrete median barriers. Increase spacing between devices.
2. Pedestrian accidents or incidents involving pedestrians.	Pedestrians on the roadway.	Build separate walkway. Install barriers between pedestrians and traffic. Restrict pedestrian movements.
	Workers in or near traffic	Install barriers between pedestrians and traffic.
3. Truck accidents or incidents involving trucks	Speeds too high or high variance in speeds.	Increase design speeds. Provide speed enforcement patrols. Add advisory speed plates. Add rumble strips. Use variable message signs.
	Work zone roadway too narrow for large vehicles.	Provide truck detours. Widen work zone roadway.
	Inadequate work zone pavement thickness to support large vehicles.	Provide truck detours. Increase pavement strength.
	Low truck speeds on grades.	Provide climbing lanes. Provide truck detours.

TABLE 3 (concluded)

ACCIDENT TYPE	POSSIBLE PROBLEM	POSSIBLE TRAFFIC CONTROL CHANGE
4. Head-on accidents or passing conflicts.	Divided highway with two-way traffic operations.	Install median barriers. Use alternate type of work zone. Shorten length of two-way traffic operation. Install channelizing devices on center line.
	Slow-moving maintenance operations.	Require work train to allow vehicles to pass occasionally. Improve signing and lighting of work vehicle. Change work schedule to periods of lower traffic volume.
5. Rear-end accidents or slow-moving vehicle conflicts.	Insufficient work zone traffic capacity.	Provide alternate routes. Change work schedule to exclude peak traffic periods. Increase capacity by routing traffic onto shoulder. Reduce length of work area. Install warning signs.
	Poor work vehicle access or egress to traffic stream.	Change work vehicle access or egress points. Provide flagger.
	Improper flagging technique.	Train flaggers. Move flagger upstream. Replace flagger with signals. Provide extra flagger positioned near the upstream end of vehicle queue.
Rear-end accidents or slow-moving vehicle conflicts. (concluded)	High variance in vehicle speeds.	Provide reasonable speed limits. Provide speed enforcement patrols.
6. Sideswipe same direction accidents, merging accidents and lane change or slow-to-merge conflicts	Insufficient taper length.	Lengthen taper. Add arrow board. Position arrow board near start of taper. Move taper upstream to increase sight distance.
	Insufficient acceleration lane length.	Lengthen taper. Install yield or stop signs on on-ramp. Close on-ramp. Build temporary ramp downstream.
	Incorrect taper placement.	Move taper upstream to increase sight distance. Add arrow board. Position arrow board near start of taper.
7. Run-off-road accidents or shoulder encroachments.	Narrow roadway.	Widen roadway. Provide speed enforcement patrols. Improve edge line delineation.

Table 4. Problem Identification and Correction by

TIME-OF-DAY OR WEATHER CONDITIONS

TIME-OF-DAY OR WEATHER	POSSIBLE PROBLEM	POSSIBLE TRAFFIC CONTROL CHANGE
1. Night accidents	Poor visibility or delineation	Illuminate or reflectorize channelizing devices. Remove old pavement markings. Add temporary pavement markers. Add temporary pavement edge lines. Add arrow board.
	Equipment or vehicles stored near roadway.	Store vehicles and equipment at location away from roadway.
2. Accidents or incidents during periods of peak traffic volume.	Insufficient work zone traffic capacity.	Provide alternate routes. Increase capacity by routing traffic onto shoulder. Change work schedule to exclude peak traffic periods. Change work zone type.
	Access and egress of work vehicles into traffic stream.	Relocate work vehicle access and egress points. Furnish flaggers.
3. Accidents or incidents during weekend periods.	Vandalized or stolen traffic control devices.	Furnish night watchmen. Increase police patrols.
	Trucks or recreational vehicles unable to negotiate curves.	Redesign work zone using higher design speed. Broadcast warning messages via commercial or citizens band radio. Lengthen tapers.
4. Accidents or incidents during inclement weather.	Poor visibility or delineation.	Remove old pavement markings and replace with new pavement markings. Install raised pavement markers.
	Poor drainage.	Improve superelevation. Patch low pavement areas. Prevent mud from washing onto roadway.

## V. IMPLEMENTATION OF CORRECTIVE ACTIONS

Once a solution to a traffic control problem or potential hazard is determined, appropriate changes are made through the corrective action process. This is defined as making changes in traffic controls or in traffic control procedures or policies, based on the analysis of work zone accident or incident data.

Information contained in this chapter will help the project manager implement corrective actions. Subjects covered in detail are: when to, how to, and who should implement changes; evaluating changes; the contractor's role in implementing changes; and liability considerations.

### A. Types of Traffic Control Changes

The traffic control changes specified in Tables 2, 3, and 4 range in complexity from simply setting up enforcement patrols, to changing the basic work zone type.

Traffic control changes have been divided into three classes in order to specify what actions the project manager should take. Minor changes mean changes that can be made quickly with little or no change in the traffic control plan of a project. Examples of minor changes would be providing speed enforcement patrols, replacing cones with barricades, lengthening a taper, adding advisory speed plates, furnishing larger advance warning signs, and changing the work schedule. Most of the changes made in a work zone will be minor.

Moderate changes require more time than minor changes and usually involve a basic alteration or addition to the traffic control plan. Examples of moderate changes would be adding an arrow board at a lane closure, moving the location of a taper, installing portable concrete median barriers, and replacing flaggers with signals.

Major changes involve a complete departure from the original concept of traffic control for a project. Many times a major change requires days or even weeks and may involve a change-order in the contract or work order. Examples of major traffic control changes would be adding a bypass roadway, reconstructing a median crossover, and adding an extra backup vehicle for a moving operation.

### B. When To Implement Changes

Corrective changes are to be implemented when a deficiency in the traffic control procedures is obvious; when analysis of project accidents or incidents point to a solution; or when solutions have been derived from similar problems in other work zones. Obvious deficiencies such as missing signs, damaged devices, or insufficient sight distance are usually discovered during regular inspections and should be corrected immediately. Project managers

themselves can analyze accident or incident data, but more than likely the amount of data available will not be sufficient for significant results and conclusions. Often the project manager will need to rely on the advice of the district traffic engineer who is assembling accident and incident data on all district work zone projects. By combining accident or incident data for the entire district, the traffic engineer may be able to determine patterns of potential hazards and traffic control deficiencies and thereby propose solutions to these problems.

Through the process of discovering and diagnosing work zone traffic control deficiencies, the project manager will develop more confidence in implementing corrective actions. If there is any doubt about what traffic control change to make, or even if a change is justified, the project manager should contact the district office to seek advice. Implementing corrective changes without thorough study and sufficient data can be counterproductive to traffic safety and can cause needless waste of manpower and equipment. The traffic department may be the logical contact, but the construction, maintenance, or design departments may also provide the solution to the problem.

If the project manager believes that suspending work could reduce hazards and potential accident situations, doing so is an option. But this is the project manager's last choice, and it should be done only when there are serious problems that cannot be solved any other way.

### C. How To Implement Changes

Corrective changes to work zone traffic control procedures should be done with minimum disruption to traffic. Additional workers and vehicles along the work zone will divert drivers' attention, so the faster the changes are performed, the shorter the time that this additional hazard is present. However, safety precautions such as reflective clothing, flashing vehicle warning lights on back-up vehicles, or the correct mode on portable arrow boards should not be overlooked for the sake of reducing the time required to implement corrective changes.

When implementing corrective changes, the work team usually will start at the upstream end of the work zone--the normal procedure used to deploy traffic control devices. A device should not be moved from its original position to the new location if there is a possibility that an additional hazard will be created by the absence of the device. For example, if it has been decided to move the entire set of advance warning signs upstream of a horizontal curve to improve sight distance, it may be best to install a new set of signs before removing the original signs.

In changing the location of a lane taper\*, the new taper should always be made fully operational before the existing taper and related traffic controls are removed. Depending on the location of the new taper, the positions of the advance warning signs also may have to be moved. If the

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\* Taper refers to the cones, pavement markings, and/or barricades used to physically define the boundary of a lane closure.

taper is moved upstream, the signing may not provide adequate warning time and distance. Downstream moves may leave such a large gap between the advance warning signs and the work zone that motorists either forget that they are approaching a work zone or else lose respect for signing that appears to them to be needless. In either case, the motorists could be surprised and confused upon discovering that they might maneuver their vehicle through a work zone.

To document the changes, if the existing traffic control plan can be used, the new positions are noted on this plan. If not, then a sketch of the proposed changes can be drawn.

Every member of the team performing the changes should have specific tasks to do. This will reduce the time spent on the roadway as well as keep unnecessary exposure to traffic to a minimum.

Corrective actions should be implemented as soon as possible. However, there might have to be a trade-off between leaving the existing hazard in place or creating a new hazard by trying to make the change under adverse traffic conditions. For example, if it is decided to implement a change that would alleviate rush hour congestion, should motorists suffer through another day of congestion and possible rear-end accidents, or should the team try to make an immediate change? The presence of the team making the safety change may be more hazardous than the congestion. Maybe the change could be implemented during an off-peak period.

Of course, each work zone is different and will have to be analyzed on an individual basis. Every corrective traffic control change must be substantiated, planned, carefully implemented, and documented to avoid creating additional hazards.

#### D. Who Should Implement Changes

The extent of the project manager's decision-making in term of implementing traffic control changes will depend on the class of traffic control change--minor, moderate, or major. Minor changes can usually be made under the direction of the project manager. These deficiencies may be identified by routine inspections and will usually involve replacing or moving devices, or other changes that the project manager feels confident in performing. Moderate changes include substantial changes to the traffic control plan, changes such as additional signing or relocation of a taper. The project manager will usually make moderate changes but may want to contact the appropriate district personnel for advice. This may be a telephone conversation with the designer of the plan or with a member of the legal department, or it may be an on-site visit by a traffic engineer. Having an advisor visit the work zone to provide traffic control advice relieves the project manager of being forced to make decisions about complex traffic control changes.

Major changes could involve a new traffic control procedure or changes in alignment, such as reconstructing a crossover. The project

manager will provide information and advice to help determine type and extent of changes required. These major changes may be costly and will require district approval before they are initiated. For major changes, the construction, maintenance, design, and traffic departments may be involved. The contractor will probably have to build the changes, thus requiring a change-order.

#### E. Contractor's Role in Implementing Changes

On projects where the construction or maintenance contractor is responsible for physically placing and maintaining traffic control devices, the contractor's role in implementing any corrective action changes must be determined before the project begins. This is the only way to ensure that needed changes are performed with minimum disruption to work activity. This type of preplanning also helps to promote a good relationship between the contractor and the project manager.

The procedures that describe what is expected of the contractor in performing corrective action traffic control changes should be detailed in the contract and in the work plan specifications. More than likely, the meaning of these procedures will need to be discussed. The time to iron out all problems that could arise from interpreting these procedures is at the preconstruction conference.

Procedures for payment of changes to the Traffic Control Plan, should changes be necessary, must be defined in the contract document. Payment for installation and maintenance of traffic control devices could be by the lump-sum-bid method, pay-item method, or a combination of the two.

#### F. Evaluating Changes

Any traffic control changes that are implemented need to be documented and evaluated to ensure that the corrections are producing the desired results. As a minimum, documentation should include: what was changed, when it was changed, why it was changed, and who changed it. Traffic control plans should be updated to reflect existing conditions. Any standards or specifications that were followed as well as instructions to contractors should be noted in the project diary.<sup>2</sup> Photography is also a good way to record the physical details of a traffic control change.

After implementing a corrective action, the project manager is expected to inspect and evaluate the change to ensure that traffic flow and work zone safety have not been adversely affected. A minor change, such as relocating one sign, may require only a drive-through inspection to see that the sign has the correct message, is in the desired location, and is properly positioned toward oncoming traffic. A moderate or major traffic control change will require a more detailed investigation, such as that described in the Inspection Procedures for New Installations section of Chapter III.

## G. Liability Considerations

Any person involved in designing, placing, or maintaining the traffic control devices in a construction or maintenance work zone will be concerned about being liable should a traffic accident occur. Although it may not be possible to avoid legal liability, there are means to protect the project manager or other highway worker should a case go to court. The information presented in this section is general in nature; the highway worker will want to consult someone in the agency to learn the state's laws concerning liability as a highway agency employee.

There are two types of tasks a highway worker can perform: those that require a judgment decision, and those that require little or no judgment. A job that requires judgment, such as road design, is called a discretionary function. Generally, if a job requires judgment, the person performing the discretionary function may be free of liability.<sup>3</sup> Another discretionary function is to make changes to existing traffic controls.

A person doing a task requiring little or no judgment, such as installing a sign at a prescribed location, is performing a ministerial function. If the sign is carelessly selected or the employee knowingly did a poor job in locating the sign, liability could be found if an accident resulted because of the improper sign. Changes may be made to functions normally considered ministerial, however, if changes are made, the reasons for the changes should be documented.

It is not known how courts will react to lawsuits resulting from accidents involving different jobs performed by highway workers, since most workers perform both discretionary and ministerial functions. To prevent or help defend against such lawsuits, the highway worker should follow these suggestions:<sup>2</sup>

- Use the state or national Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD) or other nationally accepted procedures to design and implement traffic control plans.
- Make sure that all devices present clear messages and are clean and in proper working order at all times.
- Document all work zone traffic control procedures and any changes done to the traffic control plan. The benefit of this is that the documentation proves what traffic controls were in place if accidents occur.
- Perform and document regular work zone inspections.
- Remove all unneeded equipment, building material, and traffic control devices from the work zone as soon as possible.
- To the extent possible, protect motorists, pedestrians, and workers from hazardous conditions that could lead to an accident or from injury should an accident occur.

#### H. Changes in Traffic Control Policies or Procedures

Policy is the course or method of action that guides and determines present or future decisions about work zone traffic controls. Work zone procedures are the traditional or established way of performing construction or maintenance traffic control.

Changes in policies or procedures should be initiated by the state work zone review team. This team would normally be comprised of construction, maintenance, traffic, and design engineers, utility company representatives, state police officers, FHWA representatives, and others. This team should review the annual statewide accident summary, review district suggestions, recommend policy changes, and recommend procedural changes. All recommendations will be sent to the districts to be implemented during the next construction season.

The suggestions for improving work zone traffic control procedures that are submitted by the districts are an important part of this process. All design, construction, maintenance, and traffic engineering personnel involved in work zone activities will have ideas on ways to improve traffic control procedures as viewed from their particular job position. These people should make every effort to submit ideas for improving techniques. Only in this way can the state work zone review team combine results of the statewide accident analysis with the districts' suggestions to derive policies and procedures that are meaningful to the designers and project managers who are implementing them.

## VI. PROJECT AND STATEWIDE ACCIDENT SUMMARIES

The work zone accident data process has two objectives:

1. To promote immediate analysis of work zone accidents and incidents by project managers; and
2. To develop a data base that can be used for statewide analysis of work zone accidents.

This section specifies the data that are transmitted by the project manager to the district traffic engineer (or, alternatively, to the district construction or maintenance section or utility company) and the general procedure used to analyze this data. Even though these procedures will not normally be performed at the project level, they are presented in this manual so that the project manager will be aware of how the data collected at the project level are used at the district and state levels.

### A. Data Transmitted to the District Traffic Engineer

At regular intervals the project manager will send accident, incident, and other collected information (such as traffic counts) to the district traffic engineer (or other responsible person) to be used in preparation of the project accident summary. On projects of more than a month's duration, the data should be submitted at least once a month. It is possible to submit the data with normal construction progress reports. For construction projects of less than one month's duration, data will be submitted at the end of the job. For maintenance or utility work that requires one day or less, it is necessary only to submit data when accidents occur on the job or when incidents are observed.

Some information about each accident is to be transmitted to the district traffic engineer. If a work zone accident report form is completed on an accident, then a copy is sent to the district traffic engineer. At a minimum the following information should be provided:

- . Date and time of accident;
- . Driver names;
- . Accident location; and
- . General circumstances of accident.

General summaries of incident information will also be transmitted to the district traffic engineer to aid in analyzing the project's accident experience. These summaries could take the form of several work zone incident reports in a packet, a listing of notes and dates from the project diary, or copies of completed conflict counts.

Summaries of other data such as traffic count or speed data that are used in making immediate corrective actions are also sent to the district traffic engineer. In some circumstances the district traffic engineer's office may request some of these types of data.

In addition to the information just specified, the district traffic engineer or representative should receive some documentation of changes that were made in the traffic control plan. The reasoning used in making these changes and recommendations for needed modifications in work zone traffic control policies or standards should also be documented.

#### B. Project Accident Summaries

The project accident summaries are to be done each month by the district traffic engineer or appropriate staff. The summaries use information transmitted from the project manager, the project descriptions, and the complete police accident report. Summaries are completed for long-term construction projects that were finished during the report month, and for any short-term construction, maintenance, or utility operations that experience accidents during the month.

These summaries document the accident or incident experience of the work zone by classifying the accidents/incidents by type and severity and computing the accident rate for the roadway. If the work remained in place for one month or more, the accident experience during construction is compared with accidents occurring on the road for a comparable length of time before the work activity period. The work area should be described according to the construction road type, the type of work zone, and by the occurrence of accidents in each area of the work zone. It may be useful in some cases to draw collision diagrams of the work zone to show the accident concentrations. The project accident summaries include the traffic control plan sheets for the project, notes on any immediate or short-term corrective actions that were made in the project's traffic controls, and recommendations concerning changes in policies or procedures that may be indicated based on the project's accident experience. A sample project accident summary is shown in Figure 10.

The completed project accident summaries should be sent to the state traffic engineer and the district construction or maintenance sections or the appropriate utility company.

#### C. Annual Statewide Work Zone Accident Summary

The annual statewide summary of work zone accidents is conducted by the state traffic engineering staff. The information that is needed for this summary includes project accident summaries from each district; regular traffic information, such as average daily traffic; construction information such as the number of projects constructed and utility permits issued; a listing of all police accident reports coded as work zone accidents; and regular summaries of all accidents statewide. It will also be necessary to

**PROJECT ACCIDENT SUMMARY**

Date 11-24-81 Location SR 5 at S.W. 9th St.

Project No. SR 5 - 6(81)117 Construction Road Type 4-lane undivided intersection

Period Covered 3-6-81 to 8-21-81 channelized in two stages plus resurfacing stage

	Exposing MEV	Total Accidents	Rate Acc MEV	Types												Severity	Lighting	Surface	Weather	Time														
				Location																Time														
				Advance Warning	Transition	Buffer Space	Work	Termination	Right Angle	Rear-end	Sideswipe	Head-on	Turning	Ran Off Road	Fixed Object	Overturning	Left turn	Property Damage	Fatal	Daylight	Dusk or Dawn	Artificial Lighting	Dry	Wet	Snow or Ice	Cloudy	Clear	Rain	Snow	6:00 AM to Noon	Noon to 6:00 PM	6:00 PM to Midnight	Midnight to 6:00 AM	
Before	4.51	20	4.43							5	6	2			1	6		12	8	15										5	8	6	1	
During	4.49	16	3.57	1	12	2	9	4								1		11	5	11	1	4	16						1	6	4	5		
After																																		

Collision diagram attached? Yes ☐ No ☒ \* MEV - million entering vehicles

What traffic control problems were evident? Before

Seven accidents were construction related.

Traffic queues due to capacity reduction.

What traffic control changes were made? During

No U-TURN signs were erected on median noses.

Recommendations for changes in policy or procedures based on this project.

None.

EXP =  $(2702.5 \text{ Veh/day} \times 167 \text{ days}) = 4.51 \text{ MEV}$

Rate =  $20 \text{ acc} / 4.51 \text{ MEV} = 4.43 \text{ acc/MEV}$

EXP =  $(26861 \times 167) = 4.49 \text{ MEV}$

Rate =  $16 / 4.49 = 3.57 \text{ acc/MEV}$

Figure 10 - Sample Project Accident Summary

request an accident listing (hard copy if available) by specific section of roadway for the dates that correspond to the respective construction or maintenance projects. This accident listing is used to determine the reliability of the work zone accident code on the report form.

These data should be analyzed by the staff to determine the following information:

1. The percentage of work zone accidents to total accidents, broken down by severity and roadway type;
2. The percentage change in accident rates from the before construction to during-construction time periods, broken down by the construction roadway types;
3. The number of various types of work zone accidents, including flagger involved, rear-end collision, construction object collision, etc.;
4. A summary of the short-term correction actions that were made statewide;
5. A summary of suggestions from districts for needed policy and procedural changes;
6. For a selected sample of construction projects, a comparison of the number of reports coded as work zone accidents versus the number of accidents found when a request was made by location and date; and
7. For a selected sample of construction projects, a determination of the number of accidents that were related to work activity.

Procedures that can be used for statistical analysis of accident data are specified in the publication "Accident Research Manual,"<sup>4</sup> Report No. FHWA/RD-80/016.

## VII. IMPLEMENTING THE WORK ZONE ACCIDENT DATA PROCESS

The process described in this manual is designed to aid states in meeting the requirements of FHPM 6-4-2-12 concerning the reporting and analysis of work zone accidents. The process is thoroughly described; however, for use in a particular state, there are several implementation steps necessary including adapting the process to your state's organization and capabilities, determining how completely the process should be implemented; training of people involved, and monitoring the process as it becomes operational.

### A. Adapting the Process to Your State

During development of this manual, a draft manual was implemented on a trial basis in two states. In both, the final step in implementing the work zone accident data process was to decide who in the state could carry out the responsibilities of the positions shown in Figure 2. For instance, one state did not have district traffic engineers and, therefore, decided that the duties outlined for the district traffic engineer should be performed by the district construction engineer. Also, in this state the duties of the state traffic engineer were instead performed by the design safety engineer who developed traffic control plans.

The performance of duties, particularly above the project level, must be decided on as a first step in implementing the work zone accident data process.

### B. Development of the Work Zone Accident Data Process

The work zone accident data process described in this manual can be used statewide on all types of maintenance and construction projects. It is also possible to implement it in stages and adapt it to a state's needs as the costs and benefits of the system are determined. Some possible ways that the process can be implemented in stages are: to conduct a trial in one district first; or possibly to choose certain projects where the system will be used; or, to adapt it on the project level only, which would encourage the immediate corrective actions but preclude a statewide accident summary.

In response to FHPM 6-4-2-12, many states have developed some method of work zone accident data review. The process described in this manual may be used to supplement or replace the procedure that is presently being used. Also, some states have a work zone accident report that is completed for the state legal department. In implementing the work zone accident data process, an attempt should be made to develop one accident report form that meets the needs of both the legal and engineering factions of a highway department.

### C. Training of Personnel

After the decision has been made as to how the process will be implemented, and who will fill each position described in Figure 2, a training course should be developed for project and district level personnel. The course outlined for a 1-day course used during the trial implementation is shown in Table 5. It is recommended that the class size be a maximum of 25 to 30 people. All people at the project level who would be expected to collect accident or other data should be included in the training course.

The course would normally be conducted by the state traffic engineer's office. Guest speakers who can cover some parts of the course would include a representative of the legal department to cover liability and a member of the state police to cover police cooperation and, possibly, some parts of accident investigation.

It would be advisable to prepare some supplementary materials for the manual covering areas that vary from the information given in this manual. This might include people filling certain positions in Figure 2, specific forms developed for state use, and the type of changes in traffic control that can be made by a project manager.

This training course should be repeated before each construction season to train new personnel. Short refresher courses may also be needed every 3 or 4 years for experienced personnel.

### D. Monitoring the Work Zone Accident Data Process

It is important to monitor the implementation of the work zone accident data process, especially during the first few months it is being used. This effort should include review of collected information and interviews with project managers covering use of forms, police cooperation, changes made in traffic controls, and approximate manpower being used in collecting and analyzing accident data. It is recommended someone from the State Traffic Engineers office be assigned this function.

The monitoring process should be continued throughout the construction season and finalized after completion of the statewide accident summary. The process can then be modified and/or strengthened to handle observed problems.

TABLE 5

WORK ZONE ACCIDENT DATA PROCESS (WZADP)  
TRAINING COURSE OUTLINE

I.	Introduction	1 hr
	A. Objectives of WZADP	
	B. WZADP Overview (Role of FWHA, etc.)	
	C. Levels of Responsibility	
	D. Benefits of WZADP	
	E. User's Manual	
II.	Liability Considerations	30 min
III.	Definition of Work Zone Project Limits, Accidents, and Incidents	15 min
	Break	
IV.	Collection of Accident Data	1 hr
	A. Notification	
	B. Report Form	
	C. Photography	
V.	Collection of Incident and Other Data	1 hr
	A. Incident Data and Forms	
	B. Conflict Data	
	C. Volume and Speed Data	
	D. Inspection Procedures for New Installations	
	Lunch	
VI.	Data Analysis	1 hr
	A. Accident Data	
	B. Incident and Other Data	
	C. Problem Identification	
	D. Types of Traffic Control Changes	
VII.	Implementation of Corrective Actions	1 hr
	A. Corrective Action Process	
	1. Types of Changes	
	2. Extent of Changes	
	Break	
	B. Changes in Policies and Procedures	
VIII.	Project and Statewide Accident Summaries	30 min
IX.	Concluding Remarks	30 min
	A. Logistics	
	B. Contacts with Police Agencies	
	C. Questions	

## APPENDIX A

### TRAFFIC CONFLICT COUNTS

The traffic conflicts technique is a formal procedure for collecting and analyzing information about traffic conflicts so that the project manager can more easily identify and correct possible accident-producing hazards. To study traffic control problems, the project manager usually finds a location in the work zone suitable to observe traffic flowing through the zone. Any near misses, brake light applications, or unsafe driving actions, for example, are noted and used to determine possible problems and solutions. The traffic conflicts technique removes the guesswork from locating an observation position, observing and recording specific traffic events, and determining the meaning of the collected data.

The traffic conflicts technique is easy to perform and takes little time. Within only a few hours, the traffic conflicts technique can provide good indicators of hazards. When used in before-after studies, it can both identify hazards and confirm the effectiveness of traffic control improvements.

The information contained in this appendix will enable the project manager to perform a traffic conflicts study. Traffic conflicts will be defined and data collection techniques will be discussed. Figures 11, 12, and 13 illustrate the traffic conflicts as they would be seen from the observer's position.

#### 1. Definitions

A traffic conflict is a situation in which a vehicle is required to take evasive action by braking or swerving to avoid an impending collision with another vehicle ahead or alongside. A brake light indication, obvious braking, or swerving by the offended vehicle are indicators of a conflict. A traffic conflict always involves at least two or more vehicles.

A lane change conflict is a situation in which a vehicle changes lanes into the path of another vehicle causing the offended vehicle to brake or swerve to avoid collision.

An encroachment conflict is a situation in which a vehicle passes across the boundary of its lane in either direction laterally (edge line, lane line, or centerline) at a distance less than half the vehicle's width causing the offended vehicle to brake or swerve to avoid collision.

A slow-to-merge conflict occurs when a vehicle slows or stops during its merge into the open lane, causing the offended vehicle in the open lane to brake or swerve to avoid collision.

A wrong-way lane change conflict occurs when a vehicle in an open lane approaching the transition area enters into a closed lane and an offended vehicle brakes or swerves to avoid collision with the wrong-way lane change vehicle.

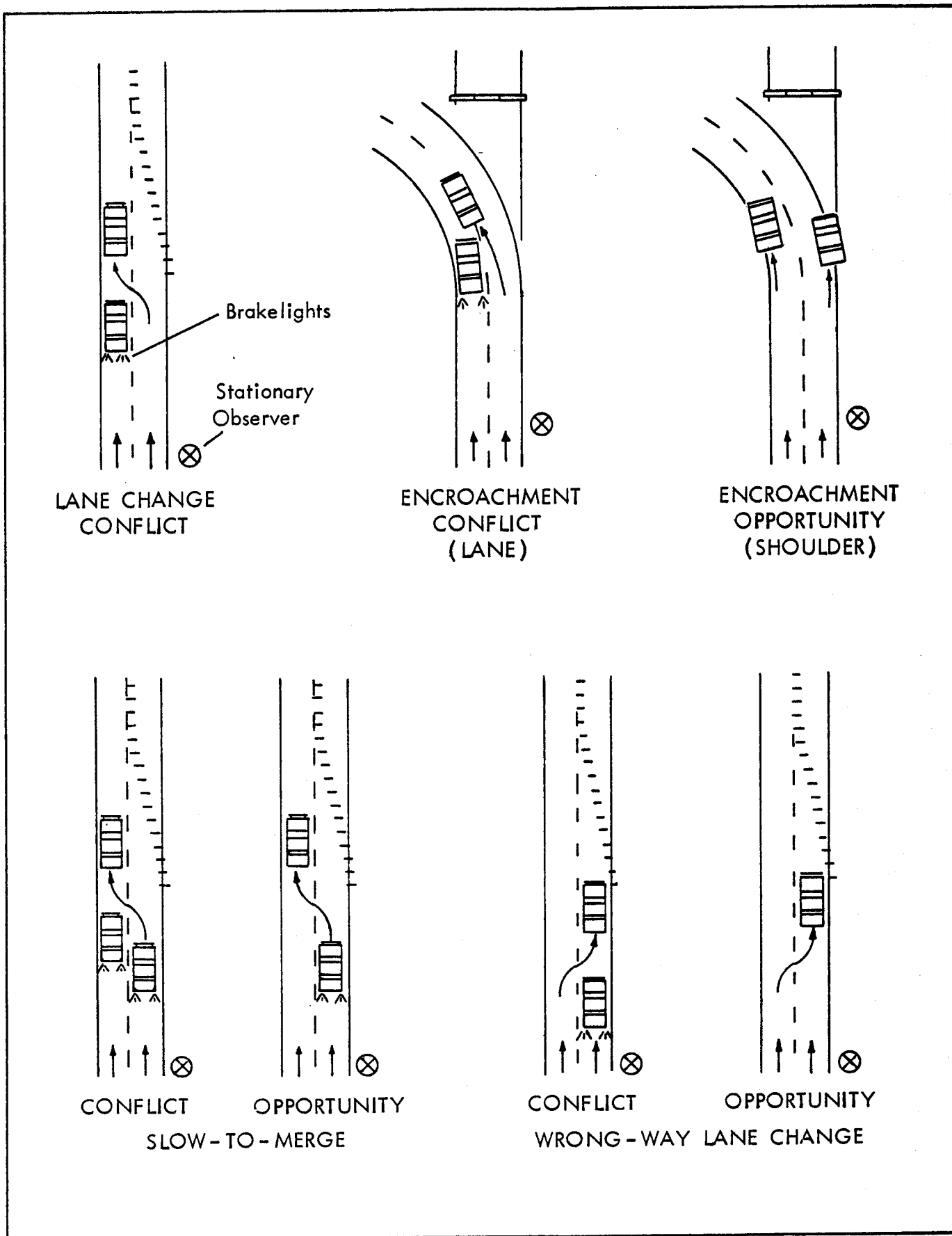


Figure 11 - Traffic Conflicts and Opportunities

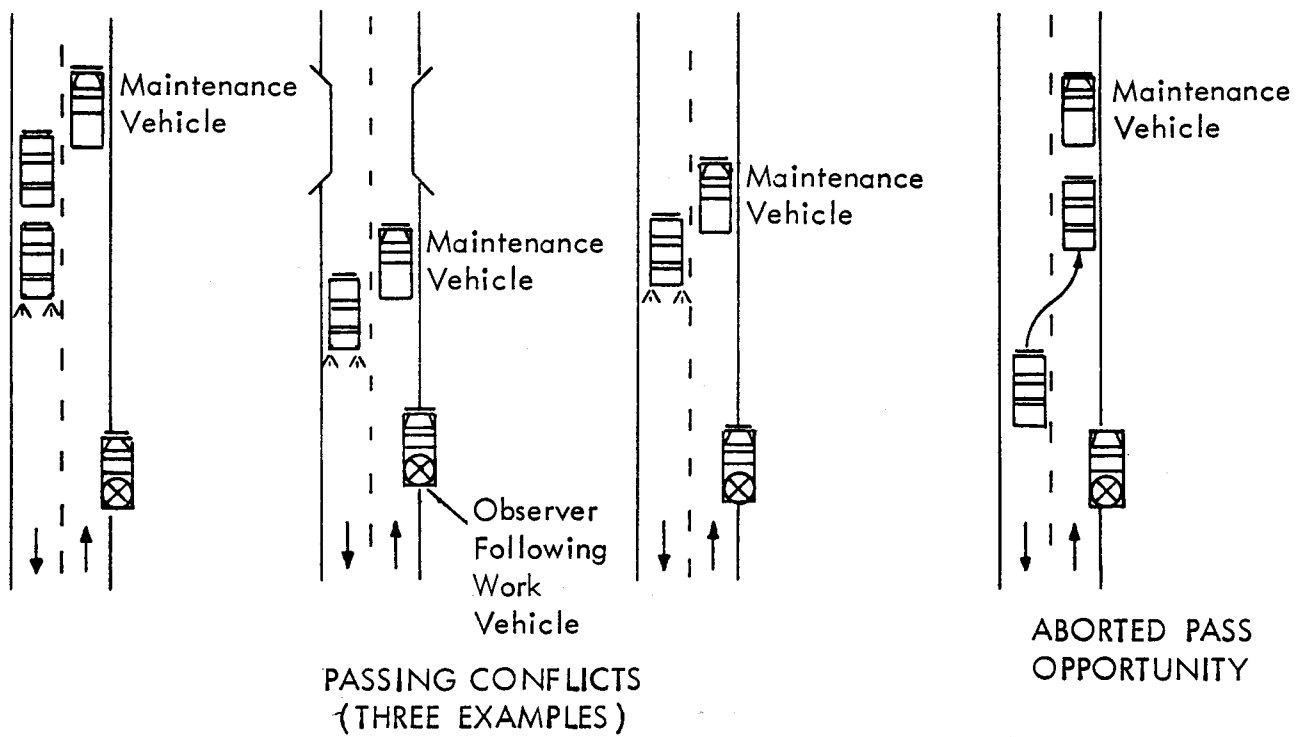
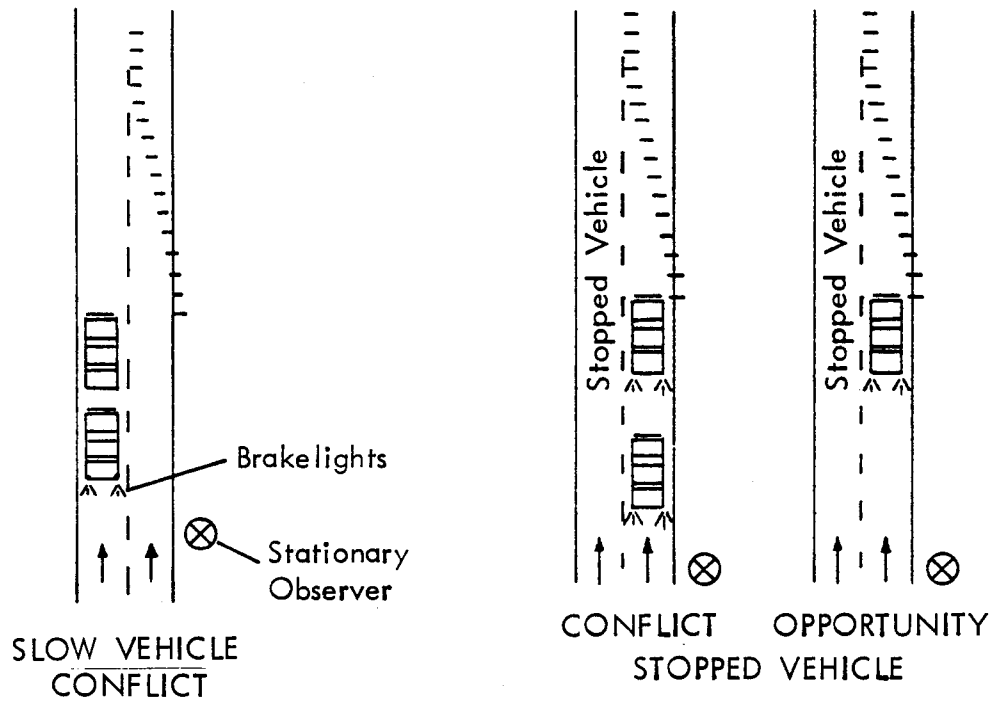


Figure 12 - Traffic Conflicts and Opportunities

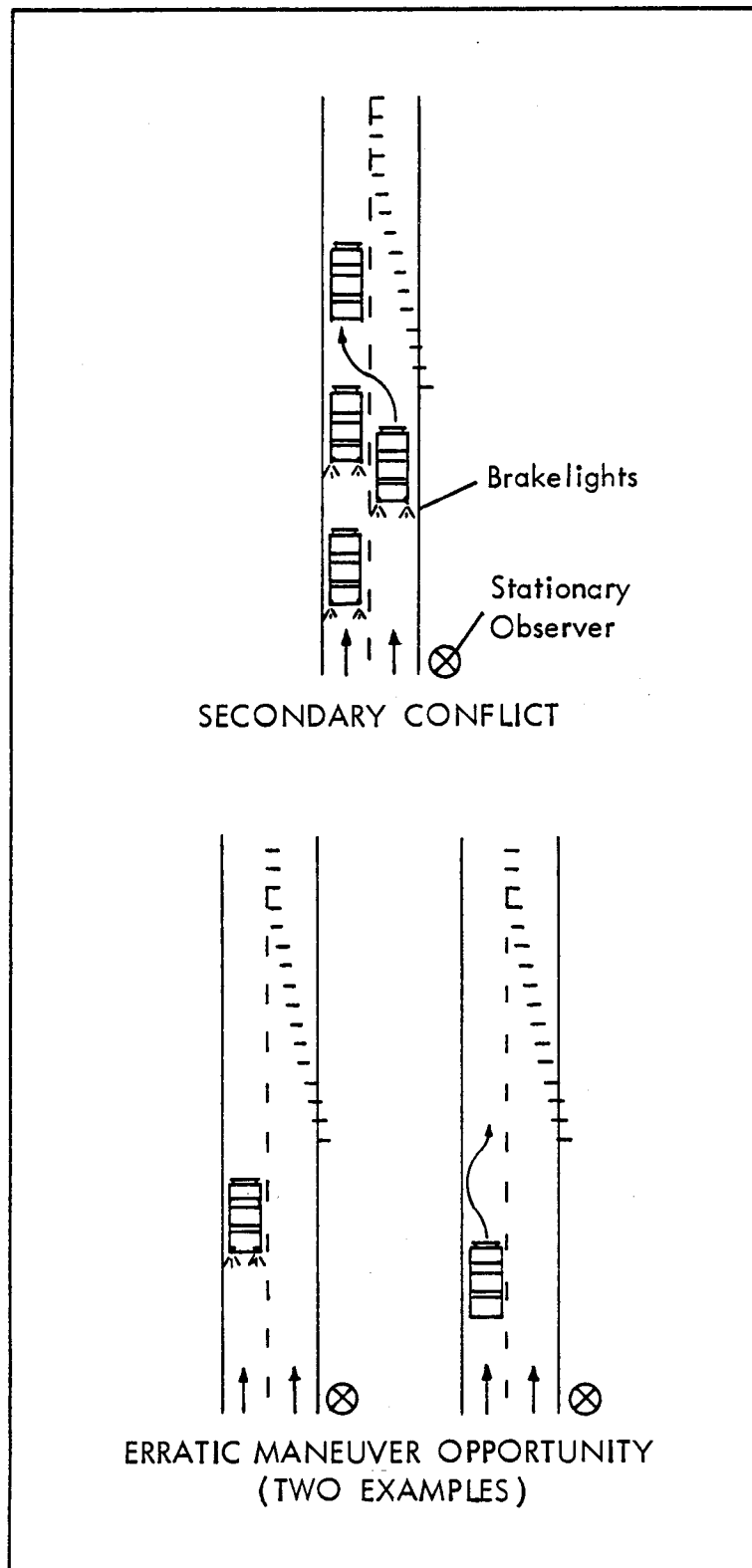


Figure 13 - Traffic Conflicts and Opportunities

A slow vehicle conflict occurs when a vehicle swerves or brakes to avoid a slower moving vehicle ahead.

A stopped vehicle conflict occurs when a vehicle is confronted with a stopped vehicle. The offended vehicle slows, stops, or swerves to avoid the stopped vehicle.

A passing conflict occurs when one vehicle is overtaking another. The conflict may be caused by a maintenance vehicle. The offended vehicle slows, stops, or swerves to avoid the vehicle being overtaken.

A secondary conflict, which involves three vehicles, is initiated by an earlier traffic conflict. It occurs when two vehicles are traveling as a pair and the lead vehicle of the pair becomes the offended vehicle in a traffic conflict and slows, stops, or swerves. The following vehicle then must take evasive action because of the action of the lead vehicle. Both the initiating conflict and the resulting secondary conflict are counted; the latter is attributed to the initiating conflict. A secondary conflict may look like a slow vehicle conflict but involves the second and third vehicles.

Other events, called conflict opportunities, occur when an unimpeded vehicle brakes, swerves suddenly, or makes another movement that is contrary to the designed traffic operational plan while proceeding through the work zone. (Unimpeded means there are no vehicles directly ahead or rapidly overtaking it in an adjacent lane.) Certain traffic conflicts have an associated conflict opportunity. These include the lane encroachment, slow-to-merge, wrong-way lane change, and stopped vehicle conflicts. Another conflict opportunity is the erratic maneuver opportunity. An example of an erratic maneuver would be a single vehicle braking as it approaches a lane taper. Since there are no other vehicles near it that would inhibit changing lanes, this is an indication of driver confusion or uncertainty. Only one vehicle is involved in a conflict opportunity.

Another event, the serious conflict, involves rapid deceleration or a severe swerve to avoid a collision. The driver has no time for a controlled maneuver. It would be a very near miss. Vehicle behavior indicating this condition would include fish-tailing, side-to-side rolling or rocking, skidding, or forward-lurching of a braking vehicle. Any traffic conflict, if severe enough, can be a serious conflict.

Other specialized conflicts may occur depending on the type of roadway or location of work zone. In urban areas, for example, pedestrians could interfere with traffic and cause conflicts. Maintenance vehicles using median turn-arounds on freeways could cause conflicts. Any work zone near an intersection could experience many different types of intersection conflicts.

Traffic events are depicted in terms of frequency and severity as follows:

<u>Traffic Event</u>	<u>Frequency</u>	<u>Severity</u>
Vehicle following	common	almost none
Conflict opportunity	↓	↓
Conflict	rare	mild
Serious conflict	↓	↓
Accident	very rare	severe

## 2. Collecting Traffic Conflicts

In order to identify potential traffic control hazards, produce supporting data, and determine corrective actions through the traffic conflicts technique, information must be properly collected, recorded, and analyzed.

Ideally, the project manager would perform the conflict observation and analysis tasks. Being responsible for the operation of the entire project, this individual is in a good position to identify and correct potential hazards. However, if the project manager is in charge of several projects and does not have enough time to perform these tasks, another member of the work zone project staff, a traffic control specialist, or a roving investigator should be assigned to collect and analyze conflicts data. This person will be identifying potential hazards and may also be responsible for recommending corrective actions, which can be determined after consulting other project or district personnel.

The conflict observer should be the same person for all conflict studies within a project unless all observers had received conflict training. Results produced from different, untrained observers may not have the same statistical validity as those produced by a single observer, even though the same basic definitions and observation techniques were used.

An alternative to relying on a single conflict observer would be to establish a team of observers who have undergone, together, a 1- to 2-week training course in observing and recording conflict events. A district (or headquarters) traffic conflicts team composed of trained traffic control specialists, to perform conflicts, volume, speed, and other studies would help ensure that valid and useful results would be produced.

If the person collecting conflicts data is not the person who will be analyzing it, then special care must be taken to make good notes and comments about events that occurred during the study period, especially if possible solutions to problems are identified. The observer and analyst must maintain close contact with one another to make sure that no important information is overlooked during the analysis.

The best location from which to observe traffic conflicts depends on vehicle speeds, available sight distance, light conditions, and the type of work zone. On high-speed roadways, such as freeways with tangent alignments, a position of 800 to 1,000 ft (240 to 300 m) from a transition is adequate.

The observer wants to be in a position to observe all traffic affected by work zone traffic controls and still be able to see brake light applications and vehicle maneuvers. On roads with lane diversions or cross-overs, the observer will want to be closer to the point of diversion if it appears that this is where problems are occurring. Traffic can be observed from either the left or the right side of the road, or even from nearby overpasses. Observers should be positioned so they are as unobtrusive as possible.

Traffic conflicts can be observed at any time of the day or night. Problems occur more frequently as traffic volumes increase. Periods of peak traffic flow are good times to count conflicts. If traffic volume increases to where congestion and stop-and-go traffic occurs, observation should be stopped until when traffic begins to flow freely again.

The longer the time period over which conflicts are observed, the more meaningful the data. Observation should start before the period of interest and end after the period of interest. Performing a study requires at least ten 15-min periods of observation. It is best to collect conflict data during periods of both peak and off-peak traffic flow.

Before starting a conflict study, the heading information on the conflict count form should be completed correctly (a conflicts count form is shown in Appendix E, Figure 20). Any sketches of traffic controls pertinent to the study are made at this time. Conflicts can be marked on the count form as they occur, but it is easier to use a count board and transfer the totals to the form at the end of each count period. A count board may be obtained from the district traffic engineer.

Recording conflicts is only part of the observer's job. The observer is also there to identify problems and possible solutions. In this respect, an important part of the conflicts count is the recording of the observer's personal comments about site conditions, unusual events, and possible solutions to any problems. The count form includes space for such comments. If other conflict types peculiar to the work zone observed are discovered, these can be recorded in one of the blank columns. Traffic volumes can be counted along with the conflicts. This will improve the accuracy of conflict rates (conflicts/volume) that may be needed to help with the analysis procedures.

After the study period has ended and before leaving the observation position, the observer should verify that all information has been recorded on the count form. This is a good time to review the data and summarize all observations and thoughts about work zone traffic control procedures and operational characteristics. Summarization should include answering the following questions:

- Have all data entries been made?
- Are they legible?

- Do the comments make sense?
- Do the existing traffic control procedures permit smooth traffic flow?
- What problems were observed?
- How can they be solved?

The traffic conflicts technique does not produce solutions to problems by merely plugging numbers into equations. The technique helps the person responsible for work zone traffic control procedures to identify problems. It also helps the observer to look for possible solutions to these problems. This formal procedure allows observations and thoughts to be put on paper for the analysis process. Further details on conducting conflict observations can be found in NCHRP Report 219, "Application of Traffic Conflict Analysis at Intersections."<sup>5</sup>

### 3. Analyzing Traffic Conflicts

Taking the same approach used in accident analysis, conflicts and accidents can be related by location, type, time of day, weather, light, and road surface conditions. For example, traffic conflicts occurring in the transition area involving vehicles changing lanes would arise out of the same traffic control deficiencies that produce sideswipe or merging accidents. Along the same line, slow vehicle conflicts are related to rear-end accidents, and encroachments in diversions or curves are related to ran-off-road accidents in curves.

All calculations can be performed with a hand calculator since the analysis process is straightforward. The first step is to summarize the counts in each column of the conflict count form, shown in Figure 20 in Appendix E, to arrive at the total of each volume, opportunity, conflict, and secondary conflict count for the study period. A typical 3-hr conflict study requires two count forms to contain all of the count periods.

In terms of severity, accidents are the most serious and most rare events, followed by conflicts, opportunities, and finally the potential for accidents from the prevailing traffic volume, which is the least severe and most common. Conflicts always involve two vehicles, while opportunities, like volume, only involve one vehicle. If the difference between traffic volume and conflict opportunities is not clear, Appendix B should be reviewed.

While adding the numbers, the events and roadway conditions that produced the conflicts should be recalled. Part of the observer's job is to identify problems and potential hazards and suggest ways to correct them. The numbers by themselves do not have much meaning until a practical, commonsense approach is used to discover work zone traffic control deficiencies.

The traffic engineer responsible for assembling and analyzing accident and incident data for the entire district may want to know how conflict statistics compare within a project and between projects. The initial set of conflict data can be used to identify problems which will lead to traffic control changes. After traffic control changes are implemented, a second conflict study should be performed to determine the effects of the changes on traffic operations. That is, a traffic control change that improves traffic flow should be substantiated by a reduction in conflicts. One can look at the conflict totals to compare the results of the before-after studies. The traffic engineer may use statistical techniques to perform this comparison. Statistical t-tests can be performed to compare the before and after opportunity, conflict, and secondary conflict averages. A procedure for conducting these tests is outlined in NCHRP Report 219,<sup>2</sup> and can also be found in general statistics texts, such as one written by Dixon and Massey.<sup>13</sup>

At times accident rates provide a more meaningful data base than accident numbers. The same is true for traffic conflicts. A conflict rate is the ratio between the number of conflicts and the traffic volume occurring during a study period. For example, for a 3-hr study the conflict rate would be the number of conflicts in the 3-hr period divided by the traffic volume of the same 3-hr period, which is recorded in conjunction with conflicts.

More than likely, this ratio will be a small number. A more convenient way to present a conflict rate is as follows:

$$\text{Conflict Rate: } R_c = \frac{(C)(1,000)}{V}$$

where  $R_c$  = conflict rate in conflicts per 1,000 vehicles.

$C$  = number of conflicts in the study period.

$V$  = traffic volume of the study period.

In a similar manner, opportunity and secondary conflict rates can be calculated by substituting the appropriate values in the above equation as follows:

$$\text{Conflict Opportunity Rate: } R_o = \frac{(O)(1,000)}{V}$$

where  $R_o$  = opportunity rate in opportunities per 1,000 vehicles.

$O$  = number of opportunities in the study period.

$$\text{Secondary Conflict Rate: } R_{sc} = \frac{(SC)(1,000)}{V}$$

where  $R_{sc}$  = secondary conflict rate in secondary conflicts per 1,000 vehicles.

SC = number of secondary conflicts in the study period.

When used in before-after studies, conflict rates are useful in determining if traffic control changes are effective in reducing potential hazards in work zones. Of course, if only one study is conducted in the before period, traffic conflicts may not adequately describe potential problems. Likewise, if only one study is conducted in the after period, traffic conflict data may not adequately confirm or deny the hazard-reducing effectiveness of traffic control changes. Two or three separate studies to identify problems and the same number of studies afterward are suggested, to substantiate the effectiveness of the improvements. As additional data are collected, a data base is developed. This will allow the analyst to make comparisons of new and existing conflict data and will help ensure that the information learned in the studies is representative of actual traffic and safety conditions in the work zone.

The numbers of vehicles and conflicts observed from one study period to the next may vary considerably. This is another reason for multiple study periods. This variability also makes formal statistical analysis more difficult.

One may wonder why accident or conflict rates are calculated if they are so difficult to verify statistically. First, once rates are determined, the analysis results may be more meaningful than an analysis of numbers alone because of the normalizing effect of the traffic volume. Second, the project manager who personally performs the data collection and analysis can intuitively make more sense of the difference between rates. That is, when "engineering judgment" or commonsense is used to interpret the meaning of data, it is more meaningful using rates. Third, rates provide a basis for comparing and relating work zone traffic control problems and solutions of projects throughout the district or even the entire state. Fourth, rates of current projects will be useful to compare with rates of future projects. This will enable highway agency administrators to determine the effects that changes in policies and procedures have on work zone safety.

## APPENDIX B

### TRAFFIC VOLUME COUNTS

There are certain types of traffic volume counts that the project manager needs when performing work zone safety and operational analyses. These include peak hourly volume, average daily traffic volume, classification, and traffic conflict volume counts.<sup>7</sup> Peak hourly volume counts in work zones are generally used for design of lanes, shoulders, and other physical features of the highway; for determining roadway capacity; and for determining periods and characteristics of peak traffic flow. The project manager is interested in knowing the periods of high traffic volume so as to adjust the project work schedule accordingly. That is, the project manager may not want to begin work until the morning period of high traffic volume starts to subside, and to remove the workers from the roadway before the evening peak period begins. There may also be a midday peak period, but traffic volume will not be as high as during the other two periods.

Peak hourly volume counts are usually recorded in 15-min increments, but 5-min increments are also used. Recording traffic volume in these increments enables the analyst to determine exactly when periods of peak traffic flow begin and end. Some highway agencies conduct volume counts for 3 hr each in the morning (6:00 to 9:00 AM), midday (11:00 AM to 2:00 PM), and evening (4:00 to 7:00 PM) to ensure that all of the peak periods are included.

The average daily traffic (ADT) volume is the total 24-hr volume that can be expected on any given day. For work zone use, ADT volumes are used for evaluating the capacity of the roadway and are an important component of an accident rate. Collecting ADT volume counts on state routes is usually done by a team from the highway agency central office staff. These counts are then published by county, state route, and highway section. The district traffic department keeps a copy of this report.

These data may or may not be collected and published annually, depending on the state. In states which do not publish such data annually, it may be necessary to adjust the counts to reflect existing traffic conditions on the highway section of interest. To do this, one obtains from the department in the highway agency that performs these counts, the appropriate multiplication factor, and applies it to the counts. An 8-hr traffic count can also be transformed into an ADT count by applying a multiplication factor. The percentage of trucks in the traffic stream should also be noted. At some construction sites, trucks may be directed to use alternate routes.

Classification counts segregate vehicles by type of vehicle, number of axles, weight, and dimensions. For work zone use, classification counts are used for geometric design of curves, clearances, grades, etc.; structural design of pavements and bridges; capacity analysis with respect to commercial vehicles; and identifying and analyzing traffic safety problems of specific classes of vehicles. Classification counts are conducted as part of a peak hourly traffic count. A simple classification such as a

passenger car-commercial vehicle separation could be used, or the various vehicle classes could be separated by type, size, and number of axles, depending on the complexity of the analysis. A spot speed data collection form can also be used for peak hour and classification volume counts by simply writing the time periods over the existing speeds in the first column. Figure 15, p. 71, is an example of a spot speed data collection form that can be used for volume-count studies.

Traffic volume counts used for traffic conflict studies are collected simultaneously with conflicts. These are total vehicle counts and are not classified by vehicle type. These counts are used in calculating opportunity, conflict, and secondary conflict rates. They help to accurately describe potential traffic safety problems.

Traffic volume can be counted manually or mechanically. Manual counts are useful when accurate vehicle classifications are required. Data collection forms, a count board, pencils, and a timepiece are all the equipment required to perform a manual volume count. If needed, the district traffic department should be able to provide an observer. Performing manual volume counts is a demanding job; observers should not be required to count vehicles for more than a few hours at a time.

Mechanical counters are useful for counting vehicles over long time periods or when an accurate classification count is not required. When mechanical counters are used, steps should be taken to protect the equipment from the work activity. Some counters use tapeswitches or road tubes to relay vehicle actuations to the recorder. In a work zone, there is a possibility that heavy equipment will destroy these sensitive electro-mechanical devices by driving over them.

Both manual and mechanical traffic volume counting techniques have advantages and disadvantages. The district traffic department can recommend and give advice on which technique would provide the most useful data for the particular data collection and analysis requirements.

## APPENDIX C

### USE OF PHOTOGRAPHY FOR DATA COLLECTION

When collecting data about work zone traffic accidents and traffic control devices that are in use, accompanying sketches or notes may be missing important details. Once the vehicles involved in a traffic accident are removed, it is difficult to describe and explain accurately the details of the accident. Photographs, movies, or videotape recordings can be used to supplement the investigation or documentation procedure. This appendix presents information on photographing accident scenes, traffic controls, and traffic operations as a help to the project manager who will use photography as a basis for analyzing work zone accidents and traffic control problems.

Any photographic equipment used to document work zone accidents or procedures will have to be of good quality. Besides producing photographs and movies that are clear and have sharp detail, good equipment is also more durable. Persons or agencies purchasing cameras should buy the best that they can afford. This applies also to flash equipment, carrying cases, and other accessories.

For still photographs, a good 35-mm SLR (single lens reflex) camera is suggested. Polaroid cameras are sometimes used to photograph accident scenes, but the quality of the photographs and the durability of the camera is not as good. Color film is preferred for showing details and producing contrast between the subjects in the photograph; black-and-white film may withstands harsher operating conditions. To reduce the expense of printing large quantities of exposed film, it is suggested the film be developed only and stored as negatives until needed.

Anyone involved in construction or maintenance work knows that the equipment and vehicles are subjected to a lot of hard use, dirt, and wide temperature variability. Construction equipment is designed for this; cameras are not. Severe operating conditions will not only shorten the life of the camera, but also will quickly ruin any film stored in the camera.

When not in use, the camera should be properly stored. The two most logical places to store the camera, the glove box and trunk of the vehicle, are actually the worst. Equipment stored in these places is subjected to extreme heat during the day and extreme cold at night. Most photographic suppliers offer a variety of camera carrying cases which will help protect valuable photographic equipment.

#### 1. Photographing Accident Scenes

Photographs of work zone accidents are an important supplement to any investigation. If the vehicles are still in their original position when the project manager arrives at the accident scene, photographs should be taken as soon as possible. (Of course, first aid and emergency traffic

control procedures have priority until medical help and the police arrive.) Photos taken should be made accessible for police investigations as well as highway application.

Photographs should show the relationship of the vehicles to each other and to the work zone. The photographs should be taken from positions on all sides of the accident. They should include close-ups of the vehicles and devices as well as distance shots far enough away to capture all pertinent details of the accident. One way to capture details is to take photographs from a vantage point such as a nearby hill. Some accident investigators use a long pole or boom with the camera attached to take elevated shots of the accident scene. Another way to take elevated shots is to photograph from the bed (or roof) of a nearby work vehicle. To obtain all possible information, many photographs are taken. Once the vehicles have been moved, the accident scene cannot be duplicated.

Photographs should depict the paths of the vehicles. Such items as skid marks; gouges, scrapes, and holes in the pavement; pieces of metal and broken glass; and oil or gasoline puddles give an indication of vehicle trajectories during the accident.

The photographs should describe the relationship of accident to the work zone. Any signs, barricades, work vehicles, etc., that were involved in the accident, as well as the entire traffic control arrangement, should be included.

The position from which the photograph was taken and a complete description of the photograph should be recorded. One way to record this information is to number each photograph at the position from which it was taken. The description is included on the accident report form or recorded separately. A way to position and label photographs is depicted in Figure 14.

When photographing from an elevated vantage point, say from the bed of a work vehicle, the vehicles should appear in the lens a known distance apart and include at least part of each vehicle in the photograph. This angle will help the investigator scale off distances captured in the photographs. For example, if some important detail was inadvertently left off the accident diagram, it can be added later if it appears in a photograph depicting its relationship to one of the work vehicles or other landmarks shown. If a lane line or a dashed centerline is on the roadway, either can be used to determine approximate distances. After the developed photographs are returned to the investigator, all pictures should be labeled with at least a number and direction so that they can be related to the accident report.

## 2. Photographing Traffic Controls

During the initial work zone inspection, the traffic control plan, including the devices and their arrangement, is documented. Photographs can be used to create a permanent record of the work zone. Still photographs, movies, videotape recordings, or photologging can be used. If still photographs are taken of the work zone, all pictures are keyed to the traffic

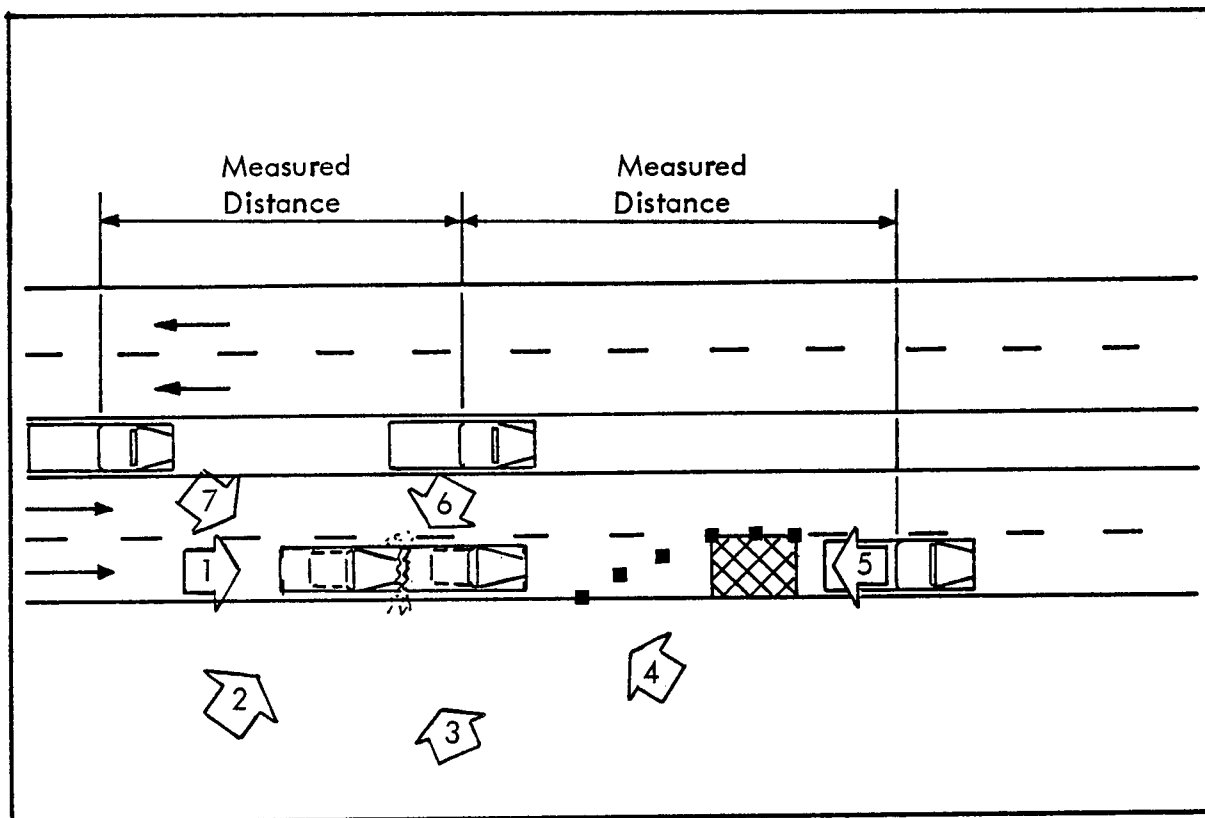


Photo Number	Description
1	directly behind the accident facing in the direction of travel
2	rear quarter - right side
3	right side showing damage
4	front quarter - right side
5	in front of the accident - taken from the bed of the truck
6	left side showing damage
7	rear quarter - left side

Figure 14 - Labeling Work Zone Accident Photographs.

control plan in a manner similar to photographing a work zone accident. Photographs show individual sign details as well as large segments of the traffic control arrangement, if possible.

Movies, videotape recordings, and photologging have the advantage of recording the arrangement of devices exactly as they are along the roadway. A person riding in a vehicle proceeding through the work zone photographs the arrangement as seen from the driver's view. The work zone should be filmed in both directions of travel. Any comments pertaining to the filming, such as position and log points of devices, are to be recorded. A tape recorder can be used for this purpose. Since the amount of equipment available for this procedure is limited, this method of documentation will probably have to be performed by someone other than the project manager and arranged through the district or central offices.

Any changes in a traffic control plan should be documented by photographic technique. Dates and times should be included. This information is used to supplement inspection reports or diary entries and can be helpful if there are liability problems.

### 3. Photographing Traffic Operations

Photographic techniques can be used to document traffic operations and analyze any problems that are evident in the traffic patterns. This type of study requires special movie or videotape equipment. Trained personnel from the district or central offices are required to operate the equipment and to extract the desired information from the film. Before requesting a film crew to design and perform a study, the project manager should try personally to discover and analyze potential hazards. Techniques such as drive-through inspections, vantage point observations, and traffic conflict studies may provide the same solutions but in a shorter time period and at a lower cost.

References are available that provide detailed descriptions of photographic equipment and techniques that could be used to perform accident investigations and traffic studies.<sup>8-14</sup>

## APPENDIX D

### SPEED STUDIES

A spot speed study is made by measuring the individual speeds of a sample of the vehicles passing a given point on a street or highway. These individual speeds are used to estimate the speed distribution of the entire traffic stream at that location under the conditions prevailing at the time of the study. This appendix details the procedures and equipment involved in conducting speed studies.

#### 1. Equipment

Although there are many ways to collect speed data, the most reliable and convenient way is with the use of radar. Radar speed meters usually have two components, the transmitter-antenna and the control unit. The control unit powers the transmitter and displays the speed measurement. Some radar units have only one component, a hand-held transmitter, and speed measurements are displayed at the rear of the unit.

Radar meters operate on the principle that a radio wave reflected from a moving target has its frequency changed in proportion to the speed of the target (Doppler effect). The meter evaluates the difference between transmitted and received frequencies and converts the result into miles per hour (or meters per second).

In radar meters which have two components, the transmitter-antenna is positioned at the edge of the roadway at about a 15-degree angle with the centerline of the roadway and about 3 ft (0.91 m) above the roadway surface. In this position the meter will indicate speeds of vehicles traveling in either direction in the adjacent two to three lanes.

#### 2. Selecting Study Location and Time

The site chosen for making speed measurements is a roadway section away from the influence of intersections, stop signs, signals, etc. A place near the roadway where the vehicle with the radar equipment can be concealed or made inconspicuous to the approaching driver is needed. The person making the speed measurements should be able to see approaching vehicles.

Usually speed studies are conducted during off-peak hours. One method that is recommended is to sample for 1 hr three times during the day, between 9:00 AM and 12:00 AM, 3:00 PM and 6:00 PM, and 8:00 PM and 10:00 PM.

### 3. Selecting Study Sample

Normally, at least 50 speeds, preferably 100, are measured during a study. Only the speeds of free-flowing vehicles are recorded. Free-flowing vehicles are those whose speed is not influenced by other vehicles; therefore, only vehicles that are traveling alone or are at the front of a group of vehicles are measured.

### 4. Study Procedure

After the radar unit has been positioned and calibrated, the speeds of free-flowing vehicles are recorded. Speeds of both directions or only one direction of traffic are recorded. The recording of the measurements is done by tallying the total number of vehicles (usually divided into two categories, cars and trucks) in a 1- to 2-mph range.

### 5. Data Analysis

Speed measurements are analyzed to determine the characteristics of the speed distribution at the study site. Some of the most frequently used speed distribution characteristics are mean speed, 85th percentile speed, and pace.

Mean speed is the average speed of all observed vehicles. It can be found by multiplying the mean speed of each group by the number of observations in that group, summing the products, and dividing by the total number of observations.

The 85th percentile speed is the speed below which 85% of the observed vehicles travel. This speed can be found by multiplying 0.15 times the number of observed vehicles and counting down this number of vehicles from the highest speed vehicle.

Pace is the 10-mph (16-km/h) range in speeds in which the highest number of observations is recorded.

Reduced regulatory or advisory speeds are typical speed-reducing techniques, but others such as rumble strips, reduced lane widths, and law enforcement personnel are also used. The presence of a police vehicle may be the most effective speed-reducing measure available, but it is costly to hire a police officer and the police vehicle.

Roadways designed for high speed operation (for example, freeways) may become more hazardous to motorists when a work zone is present if the geometric design standards of the work zone are relaxed because speed-reducing techniques are used. To promote safer traffic operations, work zone geometrics should be designed for actual vehicle speeds and not desired vehicle speeds.<sup>15</sup>

If it is thought that speed too fast for roadway conditions contributes to work zone traffic accidents, speed-reducing techniques can be implemented. The results of a speed study conducted in the suspected problem

area will provide the information needed to substantiate speed-reducing techniques or identify potential problems. A speed study is the analysis of vehicle speeds at a particular location in the work zone. It consists of a sample of vehicle speeds, which is used to estimate the speed distribution of all vehicles passing that location at that time of day.<sup>7</sup> Results obtained from spot speed studies have many uses including:

- . Determining operating speeds of different vehicle types.
- . Determining the speed distribution at a problem location.
- . Regulating and controlling traffic operations.
- . Determining the speed relationship to accidents.
- . Evaluating the effects of traffic control changes in before-after studies.
- . Geometric designing of roadways.
- . Determining the speed-capacity relationship.
- . Determining the need for speed-reducing techniques.<sup>7</sup>

Speed studies can be conducted at any location in the work zone as long as traffic is free flowing; that is, there are no intersections or traffic signals nearby and the vehicles are not traveling in platoons as a result of high traffic volume. Speed studies conducted in the advance warning, transition, buffer, or termination areas of the work zone could identify problems or potential traffic hazards that may be present. Results could indicate whether:

- . There is adequate advance warning that is properly spaced.
- . The taper is properly located and long enough.
- . Curves are flat enough.
- . Regulatory and advisory speed reduction signs are causing traffic to slow.

After a sample of spot speeds is collected, the data must be summarized, descriptive spot speed statistics calculated, and results interpreted. Figure 15 is a sample of spot speeds as collected at a highway section. Figure 16, containing the same data, depicts the procedure used to calculate spot speed statistics.

# SPOT SPEEDS

Location SR 27 @ MP 99.5  
Date 3/26/80

Hours 1:30 - 2:30 PM  
Speed Limit 55 mph Direction NB  
Recorder R Ewing

Speed Range M.P.H.	Passenger Cars		Single Units	Combo	Buses	Total Vehicles
	Local	Out of State				
40						
2						
4					1	1
6	1					1
8	III			II		5
50	III III III III		II	III		26
2	III III III III III III III III	III	1	III		48
4	III III III III III III III III III III	III III	III	III III	1	73
6	III III III III III III III III III III III	III III III	III	III III	1	78
8	III III III III III III III III III III III	III III	1	III III		69
60	III III III III III III III III III III III	III	II	III		42
2	III III III	III	1	III		25
4	III II	III		II		14
6	III	II				6
8		1		1		2
70						
2						
4						
6		1				1
8		1				1
80						
Total	2 62	58	14	55	3	3 92

Figure 15 - Sample Spot Speed Data.

Location SR 27 @ MP 99.5Hours 1:30 - 2:30 PMDate 3/26/80Speed Limit 55 mph Direction NBRecorder R Ewing

Speed (mph) X	Observed Frequency		Cumulative Frequency		X · f	X · f · X = X <sup>2</sup> · f	(X + 1) <sup>2</sup>	(X + 1) <sup>2</sup> · f
f	%	f <sub>c</sub>	%					
25/Under		.		.			676	
26		.		.			729	
28		.		.			841	
30		.		.			961	
32		.		.			1089	
34		.		.			1225	
36		.		.			1369	
38		.		.			1521	
40		.		.			1681	
42		.		.			1849	
44	1	0.3	1	0.3	44	1936	2025	2025
46	1	0.3	2	0.5	46	2116	2209	2209
48	5	1.3	7	1.8	240	11520	2401	12005
50	26	6.6	33	8.4	1300	65000	2601	67626
52	48	12.2	81	20.7	2496	129792	2809	134832
54	73	18.6	154	39.3	3942	212868	3025	220825
56	78	19.9	232	59.2	4368	244608	3249	253422
58	69	17.6	301	76.8	4002	232116	3481	240189
60	42	10.7	343	87.5	2520	151200	3721	156282
62	25	6.4	368	93.9	1550	96100	3969	99225
64	14	3.6	382	97.4	896	57344	4225	59150
66	6	1.5	388	99.0	396	26136	4489	26934
68	2	0.5	390	99.5	136	9248	4761	9522
70		.		.			5041	
72		.		.			5329	
74		.		.			5625	
76	1	0.3	391	99.7	76	5776	5929	5929
78	1	0.3	392	100.0	78	6084	6241	6241
80/Over		.		.			6561	
Total (Σ)	392	100.1			22090	1251844		1296416

• Math Check:  $\Sigma(X+1)^2 \cdot f = \Sigma X^2 \cdot f + 2\Sigma X \cdot f + \Sigma f$ 

$$1296416 = 1251844 + 2(22090) + 392 = 1296416 \text{ O.K.}$$

• Mean Speed  $\bar{X} = \Sigma X \cdot f / \Sigma f = 22090 / 392 =$ 

56.4 mph

• Sample Variance  $S^2 = \frac{\Sigma X^2 \cdot f - (\Sigma X \cdot f)^2 / \Sigma f}{\Sigma f - 1}$ 

$$S^2 = \frac{1251844 - (22090)^2 / 392}{391} = 18.0 \text{ mph}^2$$

• Sample Standard Deviation  $S = \sqrt{S^2} = \sqrt{18.0} =$ 

4.2 mph

• 85th Percentile Speed = Speed at the 85% Cumulative Frequency =

59 mph

• Median Speed = 50th Percentile Speed = Speed at the 50% Cumulative Frequency =

55 mph

• Mode = the Most Common Speed =

56 mph

• 10 mph Pace = 10mph Range Containing the Most Vehicles =

52-61 mph

Figure 16 - Calculating Spot Speed Statistics.

It can be seen from Figure 15 that the speeds are grouped in a particular manner. Without performing any analysis, the analyst can see the speeds at which most of the vehicles are traveling. For this study, the number of all vehicle types traveling at their respective speeds is totaled in the far right column. If it were desired to know how fast combination trucks were traveling, for example, statistics for this vehicle class could be calculated separately.

The numbers in the Total Vehicles column of Figure 15 should be identical to those in the Observed Frequency column of Figure 16. The remainder of the upper portion of Figure 16 depicts a series of straightforward though time-consuming additions and multiplications.

The lower portion of Figure 16 contains the equations needed for calculating some statistics and the descriptions of other statistics which are taken directly from the upper portion. The math check is included to ensure that previous calculations were done correctly. If they were done correctly, the totals of each side of the equation will be identical.

The mean speed is the average speed of all vehicles in the study. This is an indication of the speed at which a typical vehicle is traveling.

The sample variance gives an indication of how vehicle speeds are spread out. That is, the larger the variance, the more vehicles are traveling at different speeds. A large speed variance could indicate a potential problem or safety hazard, because of the friction created by fast- and slow-moving vehicles. In a study done by the American Association of State Highway and Transportation Officials (AASHTO), it was noted that vehicles traveling near the average speed were least likely to be involved in fatal accidents. That is, the faster and slower vehicles in the traffic stream are more likely to be involved in fatal accidents.<sup>16</sup>

The sample standard deviation is the square root of the variance. It also represents the variation of speeds and is in miles per hour. The standard deviation is also used in performing statistical tests.

The 85th percentile speed is the speed below which 85% of the observed vehicles are traveling. This value is found in the Cumulative Frequency % column. In this sample, the 85th percentile speed is between 58 and 60 mph; approximately 59 mph. This statistic is also used as an indicator of speed limit. In this sample, the 85th percentile speed is greater than the posted speed limit of 55 mph, which could lead to problems if the work zone is not designed to accommodate actual travel speeds.

The median speed is the speed at which one-half of the vehicles are traveling faster, and the other half slower. This is another indication of how fast the typical vehicle is traveling. In this sample, the 50th percentile speed is between 54 and 56 mph, approximately 55 mph.

The mode is another indication of typical vehicle speed. It is the most frequent speed and in this sample is 56 mph. If the sample of speeds follows the theoretical normal distribution, then the average, median,

and modal speeds will be approximately equal. In this sample they are approximately equal.

The 10-mph pace is the 10 mph speed range containing the most vehicles in the Observed Frequency column. In this sample, the pace is the 52- to 61-mph speed range. By adding the observed frequency percentages within this range, it can be seen that 68.3% of the vehicles are traveling at the 10-mph pace. This statistic shows how fast most vehicles are traveling.

Speed studies can be conducted at various locations in the work zone (for example, in the warning, transition, and buffer areas). The sample statistics would then be compared with one another to discover areas that may need remedial attention.

As stated earlier, spot speed studies by vehicle class can also be performed. If, for example, it is desired to know about potential safety hazards involving large vehicles, spot speed studies of these vehicle classes may discover statistically significant differences between large and small vehicles.

## APPENDIX E

### DATA COLLECTION FORMS

The job of maintaining a safe and efficient system of work zone traffic controls is not an easy one. The project manager is always on the alert to remedy potential hazards. If an accident occurs, the project manager should try to determine the reasons for the accident and ways to prevent similar accidents from occurring.

This appendix contains a set of data collection forms (Figures 17 to 23) that can be used by the project manager or other investigators to record information for traffic studies as prescribed in the manual. The set of data collection forms includes the following:

- . Work Zone Accident Report
- . Work Zone Accident Report Supplement
- . Work Zone Incident Report
- . Work Zone Conflict Count
- . Spot Speeds
- . Spot Speed Statistics
- . Project Accident Summary

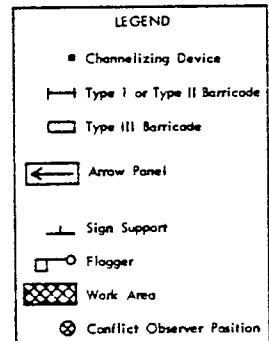
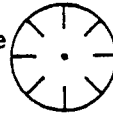
## WORK ZONE ACCIDENT REPORT

### Accident Descriptors:

Date \_\_\_\_\_ Time \_\_\_\_\_  
 Route No. (Name) \_\_\_\_\_ Driver Names \_\_\_\_\_  
 \_\_\_\_\_  
 County \_\_\_\_\_  
 Weather \_\_\_\_\_ Milepost \_\_\_\_\_  
 No. of Vehicles Involved \_\_\_\_\_ Severity \_\_\_\_\_  
 Location \_\_\_\_\_ Investigated by \_\_\_\_\_  
 Have other accidents of similar nature occurred in this zone? \_\_\_\_\_  
 If yes, give dates \_\_\_\_\_

Accident Diagram including all traffic control devices present at the time of accident, vehicles involved, etc.:

Indicate  
North



Accident Narrative: \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_























Resulting action: \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 Time and date that action was taken: \_\_\_\_\_  
 Name and title: \_\_\_\_\_

Figure 17 - Work Zone Accident Report

## WORK ZONE ACCIDENT REPORT SUPPLEMENT

### WORK ZONE ACCIDENT INVESTIGATION CHECKLIST

1. Notify police.
2. Record date, route, and driver names to be able to obtain the police investigation report.
3. Photograph traffic controls present, including reference distances.
4. Describe the accident using facts, statements, and recommendations.
  - Facts - time, description of the scene, vehicle damage, physical evidence, passenger information, etc.
  - Statements - by drivers, witnesses, and police
  - Recommendations - follow-up action to be taken
5. When hazards or problems are documented, solutions and actions taken must be documented.
6. Sketch the accident diagram. Include a north arrow, highway names and numbers, paths of vehicles, relationship to work activity, and photograph locations. Make sure the information in the diagram agrees with the other information in the report.

TYPES OF COLLISIONS	LEGEND	SYMBOLS
 Head On	 Moving Vehicle	 Channelizing Device
 Left Turn	 Backing Vehicle	 Type I or Type II Barricade
 Rear End	 Non-involved Vehicle	 Type III Barricade
 Sideswipe - Opp. Direction	 Pedestrian	 Arrow Panel
 Sideswipe - Same Direction	 Parked Vehicle	 Sign Support
 Out of Control	 Overturned Vehicle	 Flagger
 Right Angle	 Fixed Object	 Work Area
 Fixed Object		

Notes and comments: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Figure 18 - Work Zone Accident Report Supplement

## WORK ZONE INCIDENT REPORT

### Incident Type:

Observed unreported accident _____	Erratic maneuvers _____
Damaged traffic control device _____	Rear-end conflicts _____
Skid marks on vehicle track off-roadway _____	Lane change conflicts _____
Vehicles stopping in roadway _____	Slow vehicle conflicts _____
Traffic backups _____	Slow-to-merge conflicts _____
Complaint from drivers, police or workers _____	Unsafe driving actions _____
	Shoulder or lane encroachments _____

Other (Explain) \_\_\_\_\_

Description of the incident \_\_\_\_\_

\_\_\_\_\_

### Incident Descriptors:

Date \_\_\_\_\_ Time \_\_\_\_\_ Route No. \_\_\_\_\_ Job No. \_\_\_\_\_

Milepost or Location \_\_\_\_\_ Weather \_\_\_\_\_

Number of vehicles involved \_\_\_\_\_

Have other similar incidents occurred in this area? \_\_\_\_\_

If yes, explain \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

### Incident Diagram

Indicate  
North



#### LEGEND

- Channelizing Device
- Type I or Type II Barricade
- Type III Barricade
- ← Arrow Panel
- Sign Support
- Flogger
- ▨ Work Area
- ⊗ Conflict Observer Position

Resulting action: \_\_\_\_\_

\_\_\_\_\_

Time and date that action was taken: \_\_\_\_\_

Name and title: \_\_\_\_\_

Figure 19 - Work Zone Incident Report

WORK ZONE CONFLICT COUNTS

Location

Lane/Shoulder

Closure/Diversion

Moving

Page 

of

Date \_\_\_\_\_ Recorder \_\_\_\_\_

O - Opportunity      C - Conflict      SC - Secondary Conflict

Count Start Time	Traffic Volume	Erratic Maneuver	Slow Vehicle		Lane Change		Slow to Merge			Wrong Way Lane Change					
			C	SC	C	SC	O	C	SC	O	C	SC			
		O													
Total															
Rate															
Notes, Comments:															

Resulting action: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Time and date that action was taken: \_\_\_\_\_

Name and title: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Figure 20 - Work Zone Conflict Counts

## SPOT SPEEDS

Location \_\_\_\_\_  
Date \_\_\_\_\_

Hours \_\_\_\_\_  
Speed Limit \_\_\_\_\_ Direction \_\_\_\_\_  
Recorder \_\_\_\_\_

[illegible]

Figure 21 - Spot Speeds.

Location \_\_\_\_\_ Hours \_\_\_\_\_  
 Date \_\_\_\_\_ Speed Limit \_\_\_\_\_ Direction \_\_\_\_\_  
 Recorder \_\_\_\_\_

Speed (mph) X	Observed Frequency f		Cumulative Frequency f <sub>c</sub>		X · f	X · f · X = X <sup>2</sup> · f	(X + 1) <sup>2</sup>	(X + 1) <sup>2</sup> · f
25/Under		.		.			676	
26		.		.			729	
28		.		.			841	
30		.		.			961	
32		.		.			1089	
34		.		.			1225	
36		.		.			1369	
38		.		.			1521	
40		.		.			1681	
42		.		.			1849	
44		.		.			2025	
46		.		.			2209	
48		.		.			2401	
50		.		.			2601	
52		.		.			2809	
54		.		.			3025	
56		.		.			3249	
58		.		.			3481	
60		.		.			3721	
62		.		.			3969	
64		.		.			4225	
66		.		.			4489	
68		.		.			4761	
70		.		.			5041	
72		.		.			5329	
74		.		.			5625	
76		.		.			5929	
78		.		.			6241	
80/Over		.		.			6561	
Total (Σ)		.		.				

• Math Check:  $\Sigma(X+1)^2 \cdot f = \Sigma X^2 \cdot f + 2 \Sigma X \cdot f + \Sigma f$

• Mean Speed  $\bar{X} = \Sigma X \cdot f / \Sigma f =$  mph

• Sample Variance  $S^2 = \frac{\Sigma X^2 \cdot f - (\Sigma X \cdot f)^2 / \Sigma f}{\Sigma f - 1}$

$S^2 =$  \_\_\_\_\_ = mph<sup>2</sup>

• Sample Standard Deviation  $S = \sqrt{S^2} = \sqrt{\quad} =$  mph

• 85th Percentile Speed = Speed at the 85% Cumulative Frequency = mph

• Median Speed = 50th Percentile Speed = Speed at the 50% Cumulative Frequency = mph

• Mode = the Most Common Speed = mph

• 10 mph Pace = 10mph Range Containing the Most Vehicles = mph

Figure 22 - Spot Speed Statistics.

# PROJECT ACCIDENT SUMMARY

Date \_\_\_\_\_ Location \_\_\_\_\_  
 Project No. \_\_\_\_\_ Construction Road Type \_\_\_\_\_  
 Period Covered \_\_\_\_\_

	Exposure	Total Accidents	Rate	Types										Severity			Lighting			Surface			Weather			Time							
				Advance Warning	Transition	Buffer Space	Work	Termination	Right Angle	Rear-end	Sideswipe	Head-on	Turning	Ran Off Road	Fixed Object	Overturning	Property Damage	Nonfatal Injury	Fatal	Daylight	Darkness	Dawn or Dusk	Artificial Lighting	Dry	Wet	Snow or Ice	Cloudy	Clear	Rain	Snow	6:00 AM to Noon	Noon to 6:00 PM	6:00 PM to Midnight
Before																																	
During																																	
After																																	

Collision diagram attached ? Yes \_\_\_ No \_\_\_

What traffic control problems were evident ?

\_\_\_\_\_

What traffic control changes were made ?

\_\_\_\_\_

Recommendations for changes in policy or procedures based on this project.

\_\_\_\_\_

Figure 23 - Project Accident Summary

## GLOSSARY

### GENERAL DEFINITIONS

Work Zone - That portion or segment of a street or highway where a construction, maintenance, or utility activity, or the traffic control devices for that activity, impact on traffic. The zone begins with the first information received by drivers approaching a work area and ends where traffic may resume its normal operation.

Project Manager - In this manual, the person responsible for managing the day-to-day progress of the work activity and all work zone traffic controls. This position could have various other titles, including resident engineer, engineer in charge, supervisor, or foreman.

Construction Road Type - A classification of work zone in which the normal roadway type and roadway remain during the work activity. An example is four lanes divided reduced to one lane each direction.

### WORK ZONE TYPES

Roadside - Where the work activity is taking place adjacent to the traveled way (i.e., in medians, shoulders, or in the area adjoining the outer edge of the roadway).

Lane Closure - Where one or more lanes of a unidirectional traveled way are closed to traffic.

Crossover - Where traffic is channeled into one or more lanes of the roadway normally used for traffic moving in the opposite direction. On divided highways, a temporary or existing connection between the two directional roadways is used to channel traffic to the opposite side. On undivided roadways, traffic is channeled across the old centerline of the roadway so that both directions of traffic are using the same lane of the roadway.

Bypass Roadway - Where a temporary road is built to carry traffic around the work area. The bypass roadway may be either one-way or two-way.

Diversion - Crossovers, bypass roadways, or detours where traffic is diverted from its normal path but the number of lanes is not reduced.

Shoulder Closure - A roadside work activity where the roadway shoulder is closed but the number of lanes is not reduced.

### AREAS WITHIN WORK ZONES

Advance Warning Area - Begins with the first information to the drivers that they are approaching a work area. On high-speed freeways or expressways, the advance warning area may begin 1 to 2 miles upstream of the work areas. In

this area of the work zone, the driver receives information about the actual condition of the roadway ahead and the actions that will be required to travel through the work zone. Although no physical restrictions narrow the roadway in the advance warning area, there are often slowing and merging maneuvers as drivers adjust their speed and position based on their concept of the safe path through the work zone.

Transition Area - Begins at the point where traffic is channelized laterally from the normal highway lanes by devices such as cones or barricades, arranged in a taper in order to guide traffic around the work area to the part of the roadway open through the work zone.

Buffer Space - The open or unoccupied space between the transition and work areas. The buffer space provides a margin of safety for both traffic and workers by leaving room to stop before the work area if a driver fails to negotiate the transition.

Work Area - That portion where work is going on or is going to be done. The work area is completely closed to traffic and set aside for exclusive use by workers, equipment, and construction materials. Work areas may remain in fixed locations or may move as work progresses. The work area is usually delineated by channelizing devices or shielded by barriers to exclude traffic and pedestrians.

Termination Area - The area downstream from the work area where traffic returns to the normal traffic lanes of the roadway. It extends from the downstream end of the work area to the END CONSTRUCTION or END ROAD WORK sign, and may contain channelizing devices arranged in a taper.

#### TYPES OF WORK ZONE OPERATIONS

Long-Term - A construction, maintenance, or utility activity that requires traffic control and that takes longer than one period of daylight to complete, or that is performed during hours of darkness.

Short-Term - A construction, maintenance, or utility activity that requires traffic control and that takes less than one period of daylight and is not performed during hours of darkness.

Stationary - A construction, maintenance, or utility activity that moves in a continuous fashion at less than 2 mph (3 km/hr).

Moving - A construction, maintenance, or utility activity that moves in a continuous fashion at or greater than 2 mph (3 km/hr).

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